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VOLUME I

NUMBER 3

THE
UNIVERSITY OF MISSOURI
STUDIES

EDITED BY
FRANK THILLY
Professor of Philosophy

THE EVOLUTION OF THE NORTHERN PART OF THE LOWLANDS OF SOUTHEASTERN MISSOURI

BY

C. F. MARBUT
Professor of Geology

PUBLISHED BY THE
UNIVERSITY OF MISSOURI
July, 1902

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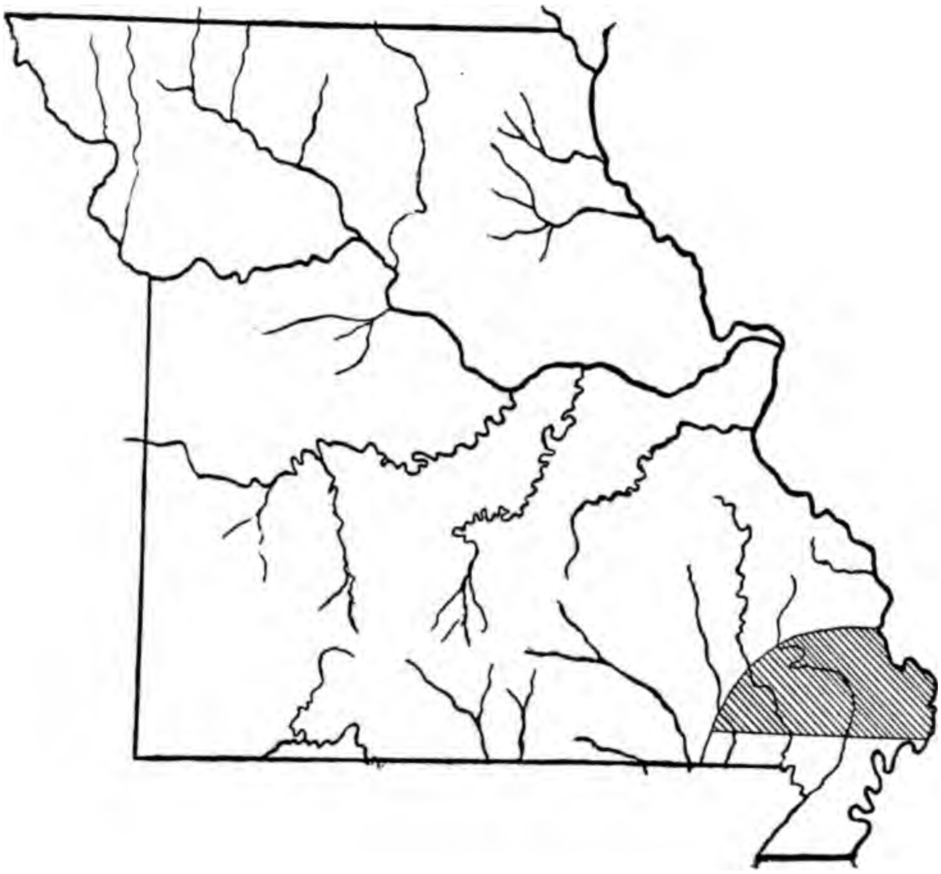
THE EVOLUTION OF THE NORTHERN PART OF THE LOWLANDS OF SOUTH EASTERN MISSOURI



SKETCH OF MISSOURI SHOWING AREA MAPPED.

Volume I Number 3

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PREFACE

Interest in the region described in this paper was first excited by some studies of geological literature which I commenced while pursuing geographic studies in the department of Physical Geography, in Harvard University, in 1894-95.

The first study of the phenomena on the ground was made during the summer of 1898 while I was engaged in geological work for the Missouri Geological Survey. Only a few days were spent in the region at this time, and the whole time was devoted to a rapid examination of the whole area, in order to gain a general view. I returned to the region again, not for the Missouri Survey however, during the Christmas vacation of 1898-99, and spent the whole time in a careful study of the northern border of the lowlands and the adjacent Ozark highlands. During the summer of 1899 I spent a little more than a month in the study of the geology and geography of the southern part of the area, particularly of Crowley ridge. During this period I was again working under the direction of the Missouri Board of Geology and Mines. During the Christmas vacation, 1901-02, I returned to the region again with three students of the department of Geology in the University, and spent the time in geological and topographic mapping in the northern part of the area.

The geological and topographic maps accompanying this paper are based on the data collected during these trips. Very little has been obtained from other sources. In fact very little was known, except by persons living in the area, until these studies were begun. In a few cases the location of the bluff line along the northern and western side of the area has been taken from the United States Land Office surveys. This is true of the line of bluffs from near Cape Girardeau to Whitewater and from Poplar

Bluff to the south line of the map. The location of the rivers, except the Mississippi, where they lie far out in the lowlands, has been taken from the same source. There are, therefore, doubtless many places where these rivers are inaccurately located, but this does not in any way affect the results arrived at concerning the development of the lowlands. The location of the Mississippi river, as well as the general topography of the gorge between Commerce and Grays Point, was taken from the maps of the Mississippi River Commission.

The maps accompanying this paper are not the result of detailed instrumental surveys, and can lay no claim to absolute accuracy, but their inaccuracies are not large enough to affect the results of the discussions which follow. The northern part of the area was surveyed hastily with the traverse plane-table, and all the localities of especial interest were carefully surveyed and sketched by foot-traverses with compass and aneroid.

The writer desires to thank the following gentlemen for assistance rendered in various ways during the progress of the work: Mr. Russell Harding, General Manager of the Missouri Pacific Railway; Mr. F. H. Britton, General Manager of the St. Louis Southwestern Railway; Mr. Louis Houck, General Manager of the Houck lines; Mr. E. F. Blomeyer, General Manager of the Southern Missouri and Arkansas Railway; Mr. McKee, of Greenbrier; and Messrs. A. T. Sweet, Otto Veatch, and E. H. Favor. The last three are students in the University of Missouri. They did the greater part of the plane-table work.

C. F. MARBUT.

Columbia, Missouri, May 15, 1902.

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THE EVOLUTION OF THE NORTHERN PART OF THE LOWLANDS OF SOUTHEASTERN MISSOURI

INTRODUCTION

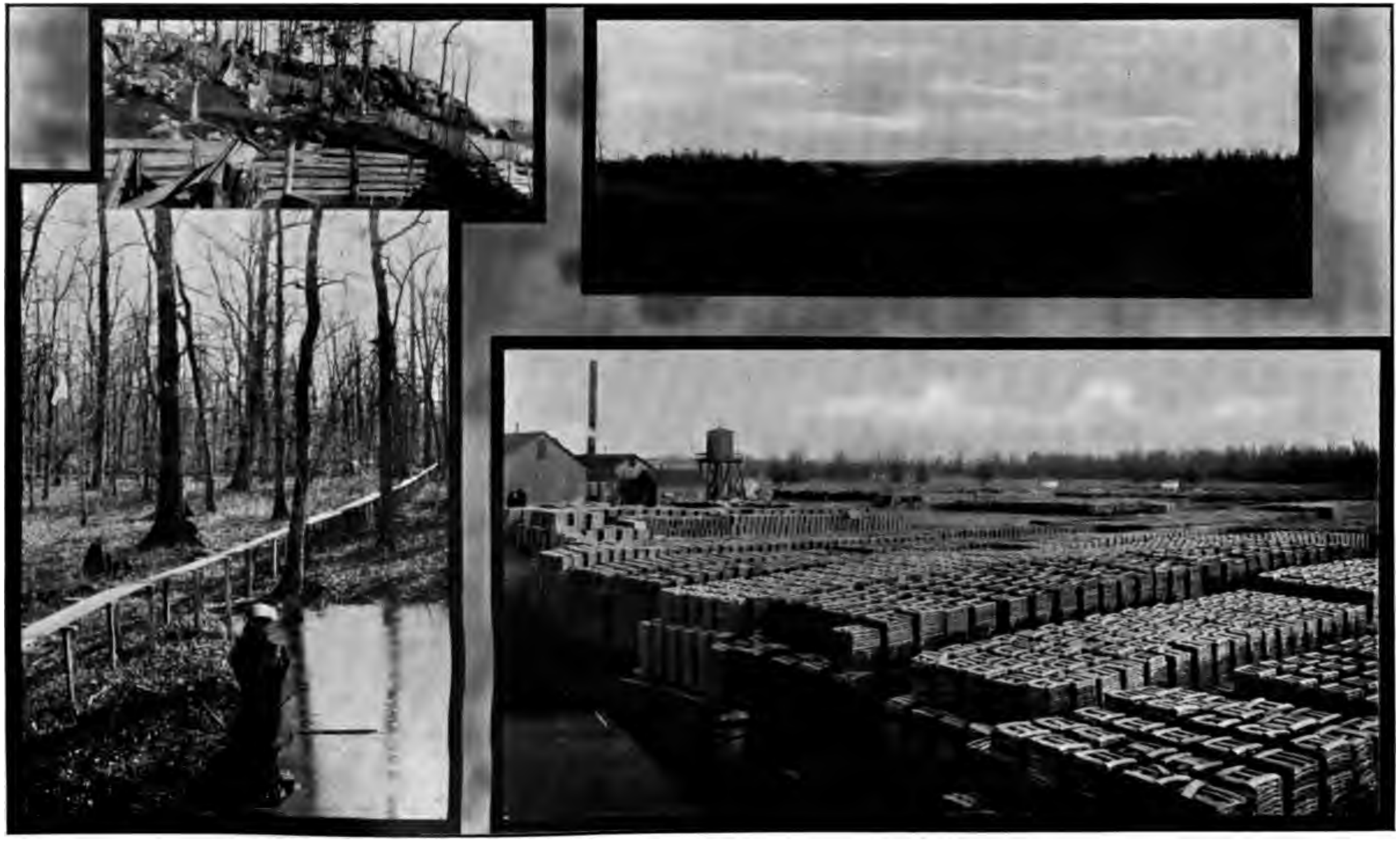
Location, Area, and Boundaries

The lowlands of southeastern Missouri are included within the areas of Cape Girardeau, Bollinger, Wayne, Butler, Scott, Stoddard, Mississippi, New Madrid, Dunklin, and Pemiscot counties. The northern and western boundary extends in a curved line from the Mississippi river, a mile south of Cape Girardeau, westward and southwestward by Dutchtown, Whitewater, Greenbrier, Wappapello, Poplar Bluff, Harviell, and Barfield to the state line, a few miles south of the last-named place. Toward the east the lowlands extend across the Mississippi river into the western parts of Tennessee and Kentucky and the southern part of Illinois. Southward they extend into the states of Arkansas, Louisiana, and Mississippi. The eastern boundary of that part of the lowland discussed in this paper is the Mississippi river, and the southern boundary is an east and west line near the parallel of New Madrid. The northern and western line of the lowlands is a steep rocky bluff, varying in steepness and height, but everywhere constituting a sharp rise from the level of the lowlands to the top of the uplands lying to the northward and westward. There is at no place along this line a gradual ascent from the lowland to the upland. The outcropping edges of the limestones of the Ozark region are exposed along the whole line. The trend of this bluff, its slopes and relation to the lowland are in all respects the same as the relation of river bluffs to the adjacent river flood plains. Although it is steep and made up of limestone layers horizontally disposed, yet the amount of talus at its base is extremely small.

The height of the top of the bluff above the lowland expresses delicately the character of the rock and the relation between the position of the bluff and the line where the Ozark beds dip beneath the level of the lowlands. The bluff is highest where it advances farthest toward the central high area of the Ozark plateau, and lowest where it recedes farthest from that position. It is about fifty feet high in the neighborhood of Cape Girardeau. Westward it gradually increases to a maximum about half way between Wappapello and Greenbrier where its height is about 250 feet. Thence southward its height diminishes to about 100 feet at Poplar Bluff, and to fifty feet again at the state line.

The eastern and southern boundaries here adopted are not the boundaries of the lowlands in these directions. The area included within the boundaries here described is about 2,500 square miles.

PLATE I.



1. Quartzite at Bell City.
2. The Lowland at Morehouse.
3. Lost Hill from Hickory Ridge.
4. Lowland Industry: Staveyard at Brownwood.

PART I. DESCRIPTION OF PHENOMENA

CHAPTER I

PHYSIOGRAPHY

The whole region consists of belts of lowland enclosing belts and isolated areas of upland. The lowland belts are continuous and have at the north end a general westerly trend, then southwesterly, and finally southerly where they cross the state line. This is the direction also of the trend of the longer axes of the upland belts and areas.

A. THE LOWLANDS

There are two main belts of lowland separated by a long ridge of varying width. They are joined by one broad belt of lowland crossing the ridge and by several river and creek valleys, all narrow.

The two belts are the Advance and the Cairo belts.

The Advance belt lies along the northern and western sides of the lowland region, and the Cairo belt along the southern and eastern sides. The whole area of the northern end of the Advance belt is included within the boundaries of the region described in this paper, while only that part of the Cairo belt lying west of the Mississippi river is included. Both belts extend southward far beyond the limits of the region described.

The Advance belt is essentially a unit. It has, however, one loop or adjacent belt, which branches off from the main belt at Allenville and runs westward and southwestward to near Greenbrier where it re-enters the main belt. It may be considered here as a loop of the Advance belt, which reaches around and encloses Hickory ridge. Its origin is not the same, however, as that of the main belt. It will be described as the Drum lowland belt.

The Cairo belt is subdivided into two subordinate belts by a low terrace-like ridge. These two belts will be described as the Morehouse and Charleston lowlands, respectively. The low terrace-ridge will be described as the Sikeston ridge. To the Morehouse lowland will be attached its northward extension, which reaches through the ridge and connects it with the Advance lowland.

1. *The Advance Lowland*

The Advance belt leaves the existing valley of the Mississippi a few miles below Cape Girardeau. It trends at first westward, then slightly northwestward, then westward and southwestward by way of Delta, Advance, Brownwood, Headquarters, Wappapello, and Neelysville to the state line and beyond.

Its width where it leaves the Mississippi is about two and a quarter miles, and its elevation is the same as that of the Mississippi flood plain opposite Cape Girardeau, and the material is of the same character also. Westward it becomes slightly broader by the recession of the bluffs along its northern side, so that at Delta its width is eight miles. In the neighborhood of Delta and north of it the immediate surface deposit is a clay, rather dense and of whitish color after exposure. This kind of deposit is thin, however, the sandy deposit which characterizes it farther eastward being reached beneath a very few feet of this clay. It does not extend far south of Delta. Whitewater river, which enters this lowland belt five or six miles north of Delta, flows southward within half a mile of the village, and to this is attributed the clayey surface deposit of the neighborhood; this deposit being of the same nature as that making up the lower flood plains of this and other streams of the eastern Ozarks before they reach the lowlands. The elevation of Delta according to the levels of the Iron Mountain railroad, checked by precise levels at Birds Point on the Mississippi river opposite Cairo, is 341½ feet above sea level. This is a little lower, about a foot, than the level of this lowland where it leaves the Mississippi. The lowland at Delta has been raised slightly, since it was formed by the deposit of clay described above. It seems, therefore, that this lowland has a very slight slope westward.

Beyond Delta the width of the Advance belt becomes rapidly less on account of the appearance of Hickory ridge, which begins half a mile northwest of the village and continues southwestward for about fifteen miles, separating the Advance lowland belt from the Drum belt lying to the north of it and with which it is connected at both ends. In fact the two lowlands are so related that they might be considered as one, and Hickory ridge as a mere isolated ridge lying wholly within it. Owing, however, to their different origins as here interpreted and described later in this report, they are considered as separate lowlands. The general character of the lowland remains the same, excepting its width, westward from Delta to the Chalk Bluff road, which passes through Lakeville and crosses the railway at Bloomfield Crossing. Here a sharp change in the elevation of the floor of the valley and of the character of the surface deposits takes place. The valley floor rises by a sort of escarpment or steep slope about ten feet, and from being of an argillaceous character on the surface, it becomes very sandy. The sand is rather fine-grained, contains some clay mixed with it, and is of a light color. It seems to be a little coarser and to have a larger proportion of sand than the alluvial deposits now formed by the Mississippi river, and less coarse and with a greater proportion of clay than the sand in the vicinity of Benton and Morley, which will be described below. The lowland here is about four and one-half miles wide. The lowland floor continues sandy for about three miles, when on approaching Castor river it again becomes argillaceous, of a character much like that in the neighborhood of Delta. There is, however, at least one low sand ridge west of Castor river, which is interpreted here as a remnant of the old sandy plain which has been elsewhere removed and replaced by clay. This ridge lies at Sturdivant station and is about eight feet high and one fourth of a mile long.

Although no levels are available, yet the evidence indicates that there is a very slight westward slope of that part of the lowland lying between the Chalk Bluff road and Brownwood. This evidence lies in the fact that the drainage from near the eastern border of the sandy part of the lowland is westward to Castor river. The slope is so slight, however, that when Castor river is very high the water flows from the river eastward through one of the sloughs, in a reversed direction, to the lower area east of the Chalk Bluff road.

From Advance westward to a point about due west of Puxico the width of this belt of lowland decreases gradually and about uniformly from about four and one-half miles to about three miles. As has been already stated, the bluffs here are high, steep, and rocky on both sides. The lowland floor is argillaceous and very flat. Water spreads over the greater part of it, which, owing to the clay soil and the heavy timber, remains during a large part of the year. Southwest of this the lowland widens rapidly by the retreat eastward of its eastern side and the rather sharp southwestward turn of the western bluffs, south of where the St. Francis river enters the belt.

The character of the floor of the lowland remains argillaceous to the state line and beyond, except a few low, long, flat-topped sandy "islands," which lie in it at various places. They furnish at the present time about the only bits of land favorable for agriculture in this part of the belt, except narrow strips along the immediate banks of the numerous sloughs. One of these islands lies about five miles east of Neelysville, and a small one at Ash Hills, east of Poplar Bluff.

In that part of this lowland belt where the floor is made up of clay, sand is encountered everywhere, according to the testimony of well-borers, at depths varying from eight to twenty feet.

This belt of lowland continues southward beyond the Missouri-Arkansas state line and finally opens out into the Mississippi flood plain south of Helena, Arkansas.

The elevation of this belt is 342 feet where it leaves the Mississippi river; at Delta it is about 340 feet. At Bloomfield Crossing, in the absence of exact levels, its elevation is estimated at 345 feet. It is probably between this elevation and 350 feet, but I give the minimum figure. East of Poplar Bluff, on the general level of the lower part of the belt, its elevation, according to the levels of the Iron Mountain railway, is about 332 feet. Southward from this it continually decreases in elevation. There is a slope, therefore, westward from the Mississippi river to Delta or apparently to "The Old Field" five miles west of the village. Then a rise to Bloomfield Crossing. From this point there is a continuous slope of the lowland floor westward and southward.

The drainage of the belt is crosswise. Whitewater river enters it north of Delta, crosses it, and follows the Morehouse lowland southward. Rum branch does likewise. Castor river enters from the Ozark highlands, crosses it, and leaves it by a rather narrow valley, through Crowley ridge, and finally flows southward through the Morehouse lowland. The St. Francis river, after following it to the state line, finally leaves it through a narrow gap in Crowley ridge and reaches the Mississippi with Whitewater and Castor. Black and Current rivers, and a small stream draining the lowland itself, all follow the lowland to where it opens into the Mississippi flood plain south of Helena, Arkansas.

2. *The Drum Lowland*

The Drum lowland belt extends from Allenville, where it leaves the Advance lowland, westard and southwestward to the parallel of Brownwood, where it re-enters the same belt. It is bordered on the north side by the Ozark hills and on the south by Hickory ridge and the Goose Pond hills, which separate it from the Advance lowland.

Its width at the beginning west of Allenville is about two miles. At Drum postoffice it is about the same, and at the extreme western end it is slightly less. The bluffs on both sides are steep and made up of the limestones and cherts of the Ozark series, capped near the eastern end by a bed of Loess.

The material of the floor is, on the surface, clay of the same character as that forming the flood plain of Castor and Whitewater rivers and other Ozark streams near the eastern end, though well within this lowland a driller reports finding sand beneath the eight or ten feet of surface clay, which extended down to a depth of about ninety feet, where the drilling stopped. No drilling has been reported from any other part of the belt.

A small part of the drainage of this belt passes out at each end, while the central part is drained southward through a gap in Hickory ridge into the Advance lowland. No elevations of points in this lowland have been determined.

3. *The Cairo Lowland*

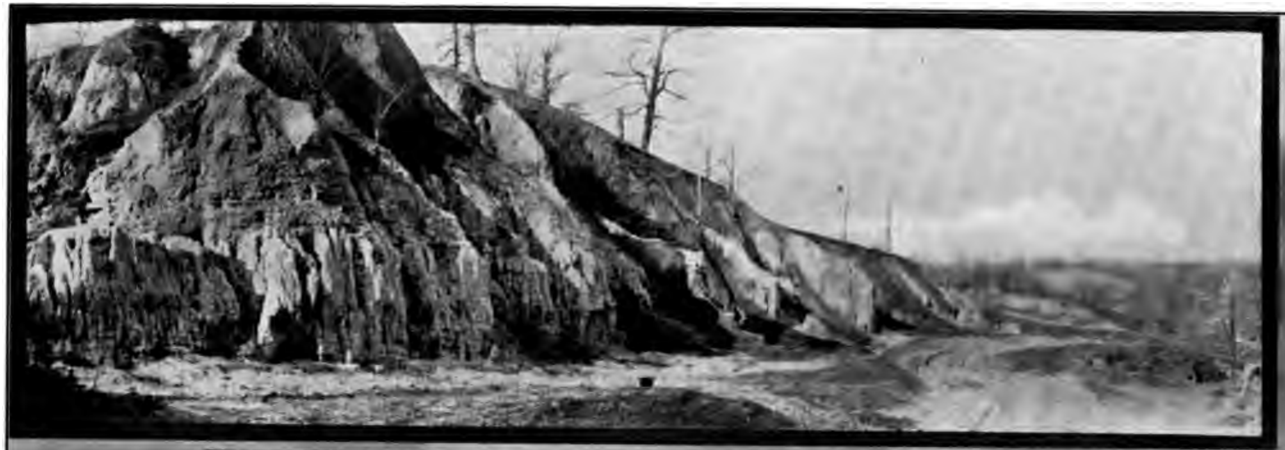
The Cairo lowland occupies the eastern and southeastern portions of the area. It will be described as the Morehouse and Charleston lowlands, and the Sikeston ridge.

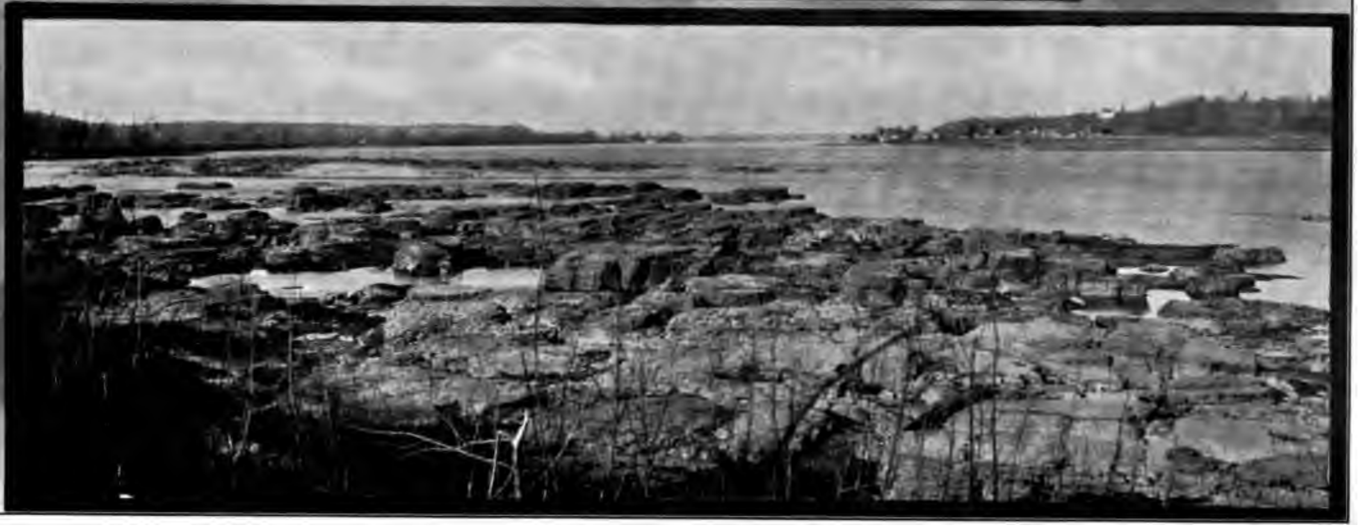
The Morehouse lowland belt leaves the Advance lowland south of Delta and pursues a nearly due southwardly course to the Mississippi river a few miles south of New Madrid. At its northern end the distance from the northeastern angle of Crowley ridge across the lowland to the hills near Caney creek, the northwestern angle of the Benton ridge, is about ten miles. If, however, we regard its width as extending only from the eastern side of Bird hill to the hills east of Caney creek, it is only about five miles wide. Opposite Bell City its width is about ten miles, between Dexter and Sikeston it is twenty miles, and on the meridian of Malden it is about twenty-five miles.

At its northern end this lowland is flat, apparently level, much of it often covered with a few inches of water. This is especially the case in the whole of the belt, except on a strip a few hundred yards wide on the eastern, southern, and western sides of the rocky "islands" standing in it and a narrow strip along the west side of Benton ridge and the eastern side of Crowley ridge. These borders are, however, the result of mere local aggradation of the lowland floor since its formation, by material from the adjacent ridges.

From two miles south of Dexter, southward, a terrace of increasing width lies between the low part of this belt and the

PLATE II.





1. Tertiary Sand with Loess Cap at Commerce.
2. Trenton Limestone in Channel of Mississippi below Gray's Point.

eastern edge of Crowley ridge. The eastern edge of this border runs due southward from near Dexter, where it leaves the ridge (Crowley), to the latitude of Kennett in Dunklin county; south of this its course is southwestward. Along the whole of this distance the limit is a definite one, there being a steep descent of about twenty feet from the level of the bench or terrace to that of the floor of the lower part of the lowland. The surface of the terrace rises slightly and about uniformly to the foot of the steep slope of Crowley ridge. The floors of both the lower parts of the lowland and of the terrace consist of sand, though that of the terrace is coarser and purer than that of the lower land.

The floor of the low part of the belt east of Kennett is level for a width of about ten miles. East of Dexter there is a series of low ridges with swampy cypress sloughs between. These extend eastward to Grays ridge. Thence eastward to within a mile of Sikeston the lowland is flat and subject to overflow. East of Kennett the lowland is under a few inches of water during ordinary seasons, and a strip about half a mile wide along Little river is permanently submerged. East of Dexter the lowland is not so often submerged. Castor and Little (Whitewater) rivers have definite channels except where locally choked up with driftwood. The banks are low so that they overflow during ordinary floods. The low ridges east of Dexter are never submerged, though they are usually only five to eight feet above the lower land of the belt. They consist of a thin upper soil of loamy clay underlain by sand. Southward they disappear before the latitude of Kennett is reached. Their extension northward has not been traced, though they do not seem to reach many miles in this direction.

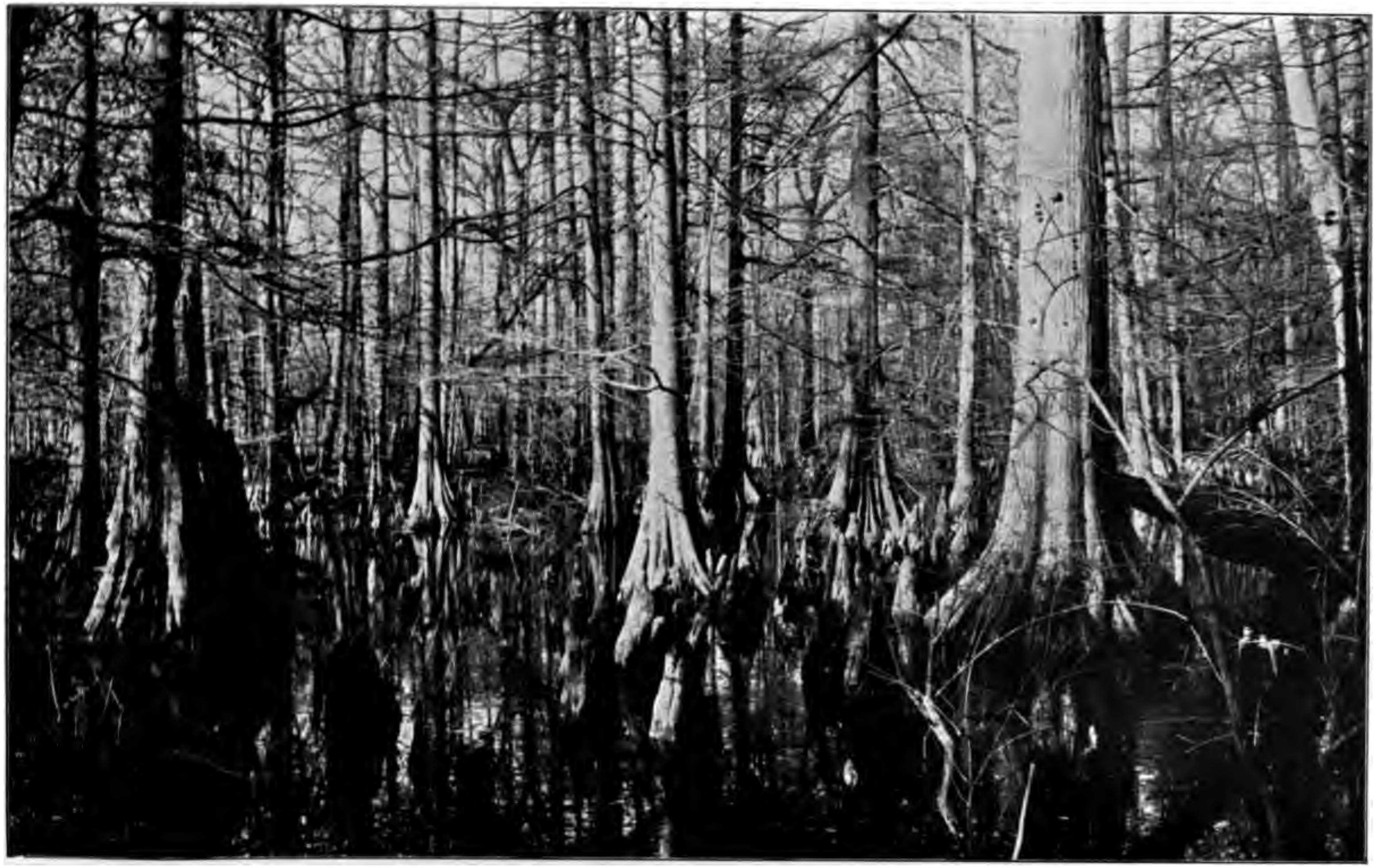
The low part of this lowland, east of Dexter, lying between Grays ridge and Sikeston, is about ten miles wide. West of this is a belt of low country consisting of low ridges and swampy belts extending westward to the foot of Crowley ridge. The most westerly of these swampy belts is continuous with the western border of the low belt east of Kennett. South of the Dexter-Sikeston line these low ridges disappear, and the low swampy strips between them unite to form the western part of the Kennett low belt. The eastern side of the Morehouse lowland belt is limited by the hills between Caney creek and Morley and thence southward to New Madrid by the low clay and sand ridge (Sikeston ridge) which ends at the latter place. Thence southward the low part of the belt is limited by the slightly higher alluvium deposited by the Mississippi in recent times. The elevation of this belt where it leaves the Advance belt is about 335 feet. At Morehouse it is 300, and east of Malden it is about 285 feet above sea level.

The Charleston lowland belt includes all the low land lying between the Sikeston ridge on the west, the Mississippi river on the east and south, and the Benton hills on the north. It begins at a point at Commerce, reaches a maximum width between Birds Point and Sikeston, and narrows to a point again at New Madrid. From New Madrid northward to the Cairo branch of the Iron Mountain railroad, the western limit is a definite one. North of this there is a gradual change from the low country on the east to a series of low sandy ridges with swampy sloughs between, much like the western side of the Morehouse lowland south of Dexter. These low ridges are in reality tongues of sand, which stretch southward like fingers from the sandy plain lying under the southern foot of the Benton ridge.

The Charleston lowland is underlain by the recent alluvium of the Mississippi river. Parts of it seem to be of the nature of a terrace deposit, older than the alluvium deposited during the present stand of the land. This statement, however, is based only on the fact that the whole plain is not subject to overflow. It is all sandy, some of it apparently more sandy than the presently forming alluvium, but this occurs chiefly toward the western side, where it would contain a larger proportion of the material of that side of the bordering higher country, which is almost pure gray sand.

Localities on this plain are everywhere higher than places on the Morehouse belt on the same meridians. The elevation of Charleston is 323 feet above sea level, while that of Morehouse due west of it is 300 feet. The elevation of Belmont, on the banks of the Mississippi river, is 310 feet, while that of the lowland east of Malden is only about 285 feet.

PLATE III.



A Cypress Slough in the Advance Lowland.

The drainage in this and the Morehouse belt follows the lowland belt, and the distribution of other features, such as low ridges, sloughs, etc., is longitudinal, while in the Advance belt this distribution is transverse to the trend of the lowland.

4. *The Duck Creek Lowland*

A rather narrow belt of lowland extends southward from the Advance lowland, south of Headquarters, re-entering the same belt southwest of St. Francisville. It is about a mile in average width, being a little wider than this at the southern end and a little narrower at the northern. The slopes at the northern end are steep, and the Palaeozoic limestones outcrop up to a height of about sixty feet above the lowland level. Further south the limestones dip beneath the lowland level, and the slopes are gradual, being made up of the Tertiary sands and of Loess.

At the southern end there are two flood plains in the belt, a central one and a higher one, existing as terraces on each side of the central one and about five feet above it. At the northern end of the belt the terrace does not exist.

The whole belt is imperfectly drained, is underlain with an argillaceous soil, and supports a growth of willow oaks. The greater part of it is drained northward into Castor river through a cypress slough called Duck creek.

5. *Minor Lowlands*

There are several narrow flat-bottomed alluvial strips extending across Crowley ridge within this area. Their westerly ends lie on a level with the Advance lowland, into which they open. Their eastern ends, however, are uniformly twenty to 100 feet above the level of the Morehouse lowland. They open out, in other words, into the Morehouse lowland twenty to 100 feet above its floor. The floors of these strips are highest also at their extreme eastern ends, from which they slope down to the level of the Advance lowland on the west. They will be described with Crowley ridge since they are features properly belonging to that rather than independent features in themselves.

B. THE HILLS AND RIDGES

Between the lowland belts lie belts of upland or ridges varying in height, shape, and material, yet all of them, with one exception, are very sharply distinct from the lowlands. In addition to the ridges there are a number of isolated hills situated in and surrounded by the lowlands. They resemble the ridges in their height, material, and relation to the lowlands. They are mere isolated parts of the ridges. There is one main ridge within the region. It enters it as a broad hilly belt lying between Commerce and Grays Point. It is an extension, west of the Mississippi, of the upland of southern Illinois. From where it enters the area, it extends westward and southwestward between the Advance lowland on the north and west and the Cairo lowland on the south and east. The towns of Benton, Kelso, Piketon, Bloomfield, Puxico, Acorn Ridge, Asherville, and Dexter all stand on it. It is cut transversely by the broad northward extension of the Morehouse lowland belt. That part of the ridge lying east of this lowland belt is called the Benton ridge or Benton hills, and that part lying south and west of this belt is called Crowley ridge.

The ridge enclosed by the Advance and Drum lowland will be described as Hickory ridge, and the low ridge between the Morehouse and Charleston lowland will be described as the Sikeston ridge.

1. *Crowley Ridge*

Crowley ridge is the most extensive of the whole group of ridges. That part of it lying within the state of Missouri is only the northern end, the southern extremity reaching more than a hundred miles into Arkansas. Its extent and shape are shown on the accompanying map, so that attention will be called only to the most prominent and significant features.

At its broadest point it is about twenty miles broad. Thence southward it contracts gradually in width to the state line. It is here traversed by the valley of the St. Francis river. The width of the ridge on the north side of the valley is only a few hundred feet. Immediately south of the St. Francis river in Arkansas, it rises again, but does not again reach the width attained in Missouri. Its upper surface, except a narrow border along the eastern side, is a rolling plain sloping gently westward. A slight exception to this general rule is that part of it lying west of Puxico. This slopes southeastward to a line running north and south through that village. In this part of the ridge the highest part is on top of the bluff at the extreme western side, within a stone's throw of the lowland. On the rest of the ridge the line of maximum elevation runs along the eastern edge, within a quarter of a mile of the edge of the Morehouse lowland. The maximum elevation of this line above the lowland east of it, is about 300 feet, and the minimum is about twenty. This line is the drainage divide of the ridge also, almost the whole of the ridge being drained by westward flowing streams. These have reduced the surface of the ridge to a past mature relief, and a large part of it is approaching old age. All the creeks have broad flood plains, and high land exists only in narrow ridges on the main and secondary divides or in isolated hills in similar positions. Near the main divide, however, the valleys are deep and narrow, but the dissection is complete. The short eastwardly flowing streams are mere deep ravines. They are all very short and small. The eastern side drops off steeply to the Morehouse lowland, but the western side, except the small part near Puxico, slopes gradually to the Advance lowland. The eastern side is a steep bluff throughout its whole length. It is steepest, however, north of Dexter. South of that it can be easily ascended in most places by a road, though it is everywhere rather steep. The eastern edge is therefore a definite line, and can be definitely located. The western edge can not be definitely located in all cases, though usually it is definite enough for reasonably accurate location. The northern end, including the west side around to Mingo station, is also a line of bluffs, except for a short distance of its course south of Advance. The course of the edge of the ridge is not straight, but it is more regular along the northern and eastern sides than along the western.

The ridge is cut into three blocks by three valleys whose floors lie at accordant elevations with the adjacent lowlands. These are the valleys of Castor and St. Francis rivers, which cross it from west to east, and Duck creek valley, which crosses it from north to south. One of these blocks is still further cut into about five smaller blocks by cross valleys of the kind referred to above, whose western ends lie at the level of the Advance lowland, but whose eastern ends lie above the level of the Morehouse lowland.

The most northerly of these cross valleys is that of Lick creek just north of Bloomfield. It does not run directly westward into the Advance lowland, but turns southward near Acorn Ridge and enters the lowland several miles south of Dudley. That part of the upland between the creek and the lowland is only five or six feet higher than the lowland. At Bloomfield its valley is about half a mile wide. Four miles up the creek, on the top of the steep eastward slope of Crowley ridge, it is still about a quarter of a mile wide, but is cut off by the slope down to the Morehouse lowland. Its level is about 100 feet above the lowland under it. Lick creek is formed by drainage which enters the valley from the sides. The head of the stream has been cut off.

The same thing has taken place at Dexter. The town stands on a flat plain nearly half a mile wide, which slopes westward to the level of Lick creek valley east of Dudley. Less than a quarter of a mile east of the railway station there is a drop from this level to that of the Morehouse lowland, a descent in this case of about sixty feet. This valley is drained westward by a stream of peculiar headless appearance. The course of the stream is due westward, but it is made up of tributaries entering it from the north and south; it extends above its upper main tributaries only as a diminutive wet weather slough. A stream, once tributary to it at the present site of the town, coming from the north, now flows into the Morehouse lowland and has cut a steep-sided gorge in the floor of the old valley.

Four miles south of Dexter another creek has been beheaded in the same way. The valley here at the eastern edge of the ridge is broader and lower than in either of the other cases cited. It is nearly a mile broad and only about twenty to twenty-five feet above the Malden terrace of the Morehouse lowland.

Still another gap, whose floor lies above the Morehouse lowland, occurs about ten miles south of Dexter, but it has not been accurately mapped. It has not yet been determined whether it is another occurrence of the same kind as at Dexter or whether it is due to an eastward meandering of the stream which excavated the Advance lowland and a later westward cutting of the stream which excavated the Morehouse lowland. Certain it is that the ridge becomes narrower in this direction, and such an occurrence is not improbable. Just this sort of occurrence seems to have taken place at the state line where the St. Francis river crosses the ridge. The valley of the St. Francis river in passing across Crowley ridge is about a quarter of a mile, or a little less, in width. The bluffs on both sides are steep and made up of soft clays and sands. The ridge on the northern side of the cross valley is only about 600 feet wide. On the south side it is slightly wider and widens rapidly southward.

Castor river crosses Crowley ridge through a valley a little more than ten miles in length. It is about a quarter of a mile wide at its western end. It widens rather rapidly to more than a mile in the middle part of its course and narrows again to but little more than half a mile where it passes the eastern edge of the ridge. In the western part of the valley one terrace lying about eight feet above the present flood plain of the river is noticeable. Where it leaves the ridge a terrace about ten feet high is noticeable. In the middle part of its course there seem to be two terraces separated by an interval of about six or eight feet.

2. *Benton Ridge*

Benton ridge is a transmississippi extension of the upland of southern Illinois. It is separated from the latter only by the narrow gorge of the Mississippi river between Grays Point and Commerce. Its northern side, in character and trend, accords with the western edge of the Illinois upland, and its southern edge corresponds in like manner with the southern edge of the latter. It is surrounded by a steep bluff, varying in height from a little less than one hundred to about one hundred and fifty feet. On its northern side the bluff descends to the level of the lowlands, but on the western and southern sides there is an apron of faint slope extending from the foot of the bluff out into the lowland for a mile or two. The top of the ridge is a dissected plain, but not in so advanced a stage of development as the western side of Crowley ridge. It is highest along its southern side. The drainage is northward and northwestward so that very little of it flows directly to the Mississippi river.

3. *Sikeston Ridge*

The Sikeston ridge extends from the southwest corner of Benton ridge southward to New Madrid. It might be considered as a southward extension of the latter, though, on account of its great difference in character from the latter, it will be considered as a separate feature. It is from one to three miles wide, generally of flat top, about twenty-five feet higher than the lowlands on each side of it, and distinctly separated from them by steeply sloping sides. It consists of a base of loose sand capped by a layer of brown loam.

4. *Hickory Ridge*

Hickory ridge lies in the northern part of the lowland area and is entirely surrounded by it. Its eastern end lies just west of the Iron Mountain railway track between Delta and Allenville. Its western end lies about a mile and a half north of Brownwood. It is not an unbroken ridge from one end to the other, but is cut into several small areas by cross valleys. The hills at the extreme western end bear the local name of Goose Pond hills. In the vicinity of Delta and Allenville its slopes are steep and rocky. West of Allenville the northern slope is not bluff-like, but it is everywhere a steep slope. The southern side is a little steeper and has a greater number of localities where the slope is rocky and bluff-like. It is about a mile broad at its eastern end and tapers to a sharp point at the western. Its height varies from nearly 200 feet at the eastern end to about 100 at the western.

The isolated hills located on the map and referred to above are all situated between the northern end of Crowley ridge and the western side of Benton ridge. They are all of essentially the same character and are also of the same character as the adjacent parts of the ridges named. They bridge a large part of the gap between the two ridges by showing their former continuity. Each hill has its longest axis running north and south. Each has a steep slope on the northern end, extending down to the level of the lowland, and aprons of clay and sand extending outward from the southern end and from the southern halves of the sides. The apron extending out on the western side is broader than that on the eastern. Each is drained southwestwardly. They are all of about the same height, but their areas vary. Their maximum height is about 200 feet above the adjacent lowlands. They slope gradually southward, but not down to the level of the lowland. There is a bluff here as well as elsewhere.

CHAPTER II

GEOLOGY

In the description of the rocks of the region those of the northern rim of the lowlands will be included, as well as those of the lowland proper.

The rocks of the region are all of sedimentary origin. From the point of view of age they fall into two main groups, the one very old, the other very young.

For physiographic purposes also a division into two groups is most convenient, and the dividing plane is the same in the two cases.

The grouping of the rocks according to age is shown in the following table:

Recent.	Alluvium.
Pleistocene.	Loam. Loess.
Tertiary.	Gravels (Piketon). Sands (Benton). Clay (Idalia).
Palaeozoic.	Trenton limestone. Calciferous limestone and sandstone.

The grouping of the rocks from the physiographic point of view is into the indurated rocks and the non-indurated rocks. The indurated rocks are very old, the non-indurated rocks are very young.

A. THE INDURATED ROCKS

These rocks are of Palaeozoic age and belong to the Cambrian and Lower Silurian periods of geological time. They consist of limestones and sandstones.

The geological studies for this paper were confined chiefly to the area of the lowland proper so that for the description of the rocks of the northern rim I shall depend chiefly on the studies of Shumard which were published in 1855.

With the exception of a capping of Loess which thins out westward, the Palaeozoic rocks make up the bluffs along the whole northern and western border of the Advance lowland belt. At Cape Girardeau this bluff is made up exclusively of thin-bedded Trenton limestone. It is here about fifty feet high. Westward the bluff becomes slightly higher, and at Rock Levee it is about eighty feet high and still made up of Trenton limestone. A short distance west of this the underlying Magnesian limestones appear at the foot of the bluff and rise higher toward the west. In the vicinity of Hubble creek the Trenton finally disappears from the top of the bluff, and west of this the whole bluff is made up of the rocks of the Ozark series. The Trenton is a fine-grained limestone, with very little chert, varying in color from a white to dark blue.

Shumard describes the occurrence of the first Magnesian, the Saccharoidal sandstone, the second Magnesian, the second sandstone, and the third Magnesian from the western part of Cape Girardeau county. The region from which most of these occurrences were described was not visited. West of Whitewater, however, no occurrences of sandstone, except a few isolated blocks, have been seen, and the whole of the bluff is composed of what seems to be the lower cherty limestones of the Ozark series.

South of the eastern end of the Advance lowland belt the Trenton limestone appears again in the northern bluffs of the Benton ridge. Its outcrop extends along the whole extent of the northern side of the latter, the Ozark limestones appearing beneath them toward the western end. Their outcrop runs southward down the gorge of the Mississippi, finally dipping beneath the level of the river about three miles above Commerce. The uneven upper surface of the Trenton, just above where it finally disappears, forms a belt in which many rocks project above the water, while others are buried by only a few inches or feet, thus forming the "Grand Chain" of the Mississippi river boatmen.

Certain sandstones between the Grand Chain and Commerce, referred to by Shumard, who apparently thought they belonged to the sandstones lying immediately above the Trenton, are now known to belong to the younger series of rocks of the region and will be described below.

West of Benton ridge Silurian rocks occur in all the bluffs of the various hills and ridges on the south side of the Advance lowland. They are confined to the lowest member of the series, the third Magnesian limestone. In the northern end of Bird hill the top of the cherty limestone is about sixty feet above the adjacent lowland. It outcrops on either side a short distance south of the northern end, but disappears beneath the lowland level somewhere north of the southern end of the hill. The same conditions exist on Cow hill and Lost hill. On Ringer hill, however, the limestone outcrops around the whole base except the extreme southern part.

On the northeastern corner of Crowley ridge the top of the limestone bluff is about eighty feet above the level of the lowland. Westward it descends slightly to about twenty-five feet due south of Advance and less than this south of Brownwood. South of Sturdivant it has again risen to sixty feet and maintains this height to Puxico, except a short space between Duck creek valley and Castor valley above Leora where it is a little less. West of the meridian of Puxico, the top of the limestone rises in the bluffs to a maximum of about 250 feet due west of the town. South of this the top of the limestone declines uniformly and finally disappears below the level of the Advance lowland a few miles south of Mingo station.

From this description it is seen that the top of the limestone is quite uniform in height along a line running slightly north of east, and that southward it dips beneath the level of the lowlands, the line connecting the points of disappearance beneath this plane being nearly an evenly curving line.

Between the Silurian limestones and the younger rocks of the region lies a wide time interval. The latter part of this interval is represented by erosion. How many of the immediately succeeding formations were deposited and then subsequently eroded away can not now be determined, though it is within the bounds of reasonable inference that most of the upper Silurian and Devonian formations were deposited. They outcrop in the northern part of Cape Girardeau county and northward, and by their marine fossils and total lack of signs of terrestrial or near-shore marine conditions during their deposition, show that they originally had a much greater distribution southward and westward. The fact also that the Lower Carboniferous rocks and the Coal Measures occur only a little further north and east, places them in the same category. The Lower Carboniferous rocks have the same character, so far as lack of nearness to land area during deposition is concerned, as those just cited. The Coal Measures, it is true, show positive evidence of deposition close to land areas, but their occurrence both northeast and southwest of the area, and the occurrence of isolated areas on the top of the Ozarks far from the edge of any continuous coal field, indicate clearly their former extension over the whole of southern Missouri and northern Arkansas.

The erosion interval referred to above seems to have begun therefore not earlier than late Carboniferous times and lasted until the beginning of the deposition of the clays of Crowley ridge, probably in early Tertiary times. However this may be, the interval was long enough to wear the country down to a nearly even surface. No trace of a sharp ravine has been found in it, and the even line of contact with the overlying beds, and of disappearance beneath the lowland plane show the surface to have been even.

B. THE NON-INDURATED ROCKS

The younger, non-indurated series of rocks of the region consist of six well defined members, when classified on the basis of lithological character and composition. They are, beginning with the lowest, dark and drab shale and clay, sands with occasional clay beds, gravels, loams and loamy clays, terrace loams, and alluvium.

1. *The Shale (Idalia)*

The shale bed is found only in Crowley ridge and usually only in the lower part. Toward the northern end of the ridge it is uniformly dark in color, and where freshly exposed, it is black, very much resembling the soft black shales of the coal measures. South of Dexter it is gray to drab in color and slightly less shaly in structure. It outcrops along the steep eastern side of Crowley ridge, but the actual exposures, on account of the loose overlying sands and clays, are rare. It was not seen anywhere along the northern end of the ridge nor for several miles south of the end. The next overlying bed seems to lie directly on the Ozark limestones. The latter bed disappears beneath the base of the bluff about three miles north of Bell City. From this point southward the sands seem to extend to the base of the bluff until Bell City is passed. At Ardeola the lower sixty or eighty feet of bluff are made up of the shale bed. From this point southward the shale occurs in most of the ravines and seems to rise slightly higher in the bluff. It was not seen anywhere in Castor river valley, but at Idalia it was exposed fifty or sixty feet up in the bluff, though the top of the bed was not located. Between Idalia and Dexter the bluffs were not carefully examined. There is, however, a doubtful occurrence of the bed about a mile north of the latter place. In the vicinity ot Dexter, although the exposures down to the base of the bluff are fairly good, the shale bed was not seen. The sands extend down to the level of the lowlands. The same conditions continue southward from Dexter for several miles. The ravines in the eastern edge of the ridge expose nothing but sand. About seven miles south of town a shale bed appears again, but it is of a grayish color and slightly coarser material than further north. It is exposed about fifty feet above the lowlands at this point, but less than a mile north of this locality an equally deep and fresh ravine exposes nothing but sand. At Chalk bluff on the state line where the ridge is crossed by the St. Francis river, Call[1] states that this shale or clay bed, as he terms it, is exposed up to about forty feet above the river. Between this and the last locality cited the outcrops were not studied in detail. In Arkansas Call shows that the bed has a great thickness and underlies the ridge from Chalk bluff to Helena. The bed has not been encountered anywhere along the west side of the ridge. It is met with in a few places in the heads of the streams flowing westward from the high divide at its eastern side. The most prominent exposure on this side is about two miles south of Piketon where the top rises about sixty feet above the valley bottom.

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[1] *Geol. Surv. Ark.*, Vol. II. for 1889, p. 114.

The relation of these beds to the overlying sands has not been clearly established. A good exposure of the contact between the two series of deposits has not been found. There are two facts, however, which enable one to infer the relation, and since both point to the same conclusion the inference can not be considered to be wholly unfounded. The upper surface of the clay bed is not even. The description given above shows that it rises and falls in broad undulations. It reaches a maximum height above the lowland plane near its northernmost exposure and descends below the level of the same plane south of Dexter. The change from the pure clay shale to the nearly pure sands of the overlying formation is a rapid one; while the actual contact has not been seen, yet a sufficiently near approach has been made to warrant the statement. At its northernmost outcrop the shale lies only a few miles from the southernmost outcrop of the Ozark limestones. If no erosion of the shale has taken place, this was the relation of this part of the shale bed to the shore-line at the time of its deposition. The shale could hardly have had the character which it now has, had it been deposited so close to a shore line where chert pebbles were doubtless abundant. It seems more probable that the shale bed was eroded before the deposition of the sands. The inference, therefore, is that the sands are unconformable on the shale.

2. *The Sand (Benton)*

The sands and gravels will be described separately. The sands constitute the lower of the two members and immediately overlie the Tertiary shales and clays. They vary considerably in character, the variation being apparently a function of the distance from the Mississippi river. They are of late Tertiary age, probably Lafayette.

They underlie the whole area of Crowley and Benton ridges and apparently also the whole of Sikeston ridge. They constitute the larger part of the mass of the isolated hills between Crowley and Benton ridges. They probably occur as a thin layer between the Silurian limestones and the Loess of Hickory ridge. They are thin at the northern end of Crowley ridge, finally thinning out on Hickory ridge or south of it, and thickening southward to nearly 200 feet south of Dexter. On the Sikeston ridge their thickness is not known, since the bottom of the formation has not been determined. They thin out about the northern edge of Benton ridge, but reach a thickness of about 200 feet at the southern edge.

Along the eastern side of Crowley ridge they reach a thickness great enough to enable them to become noticeable beneath the mantle of overlying and overwashed Loess, about three miles north of Bell City. A mile north of the village they extend from the base of the bluff to within thirty feet of the top. The lower beds consist chiefly of quartz sand rather well waterworn, containing a small percentage of small chert grains and a few small well worn and polished quartz and quartzite pebbles. The color of these beds when bleached is gray, but a short distance back from the edge of the bluff they are reddish. Overlying this are sand beds of finer grain, interstratified with whitish clay beds. The upper portion of the lower sandy portion is here locally cemented into a hard quartzite, which outcrops along the bluff for a mile or more above and below the town.

The same relation characteristic of a sandy lower member and sandy and clayey upper member, seems to hold at Bloomfield and further southward. At Bloomfield the sand occurs abundantly in the bottoms of the hollows and the clays occur higher up the hills, but still under the gravels. South of Dexter the lower sandy beds are about the only beds exposed for five or six miles. South of this the higher beds appear in a series of higher hills and seem to dip slightly southward. At Chalk Bluff the upper beds or at least sandy clay beds fill most of the interval between the Tertiary shales and the overlying gravels.

In the western part of Crowley ridge the reddish sands appear immediately beneath the Loess or the gravels. The sandy clay upper member of the series was not identified with certainty. On account of the similarity of this bed to certain clays which were thought to belong with the Loess, it is difficult to make a satisfactory distinction between them by an examination of the beds themselves when their stratigraphic relations are not clearly shown by the beds in contact with them. The western part of Crowley ridge is lower than the eastern, and since neither these sandy clay beds nor the overlying gravel beds occur except on a few high points, the presumption is that they have been eroded away. The existence of an upper sandy clay member and a lower sandy member, as here described, does not seem to obtain in Arkansas, according to the sections described by Call,[1] and in fact such a relation in Missouri has not been demonstrated beyond any doubt. The facts obtained, however, indicate that such a conclusion is warranted. Call's sections indicate that nearly the whole bed in Arkansas has the characteristics of the upper bed in Missouri. This is indicated by the relative thickness of the clayey member and the thinness or entire absence of the sandy member at Chalk Bluff.

The facts so far observed indicate that the character of the sands remains much the same throughout Crowley ridge with the exception of an increasing fineness of grain southward.

In Benton ridge the sands are well represented. The thickness has already been given. At Commerce the base of the bluff is composed of coarse reddish to brownish sands containing rather abundant small pebbles of quartz and dark or purple quartzite and occasional chert. This is overlain by a white, very fine-grained micaceous sand mixed with a whitish clay, the whole appearing in the bluff like a bed of clay (Plate I). Westward the lower sandy bed rises in the bluff and makes up the larger portion of it. The upper member is not so conspicuous though it seems to be present. The sands washed out from the ridge south and west are rather coarse, whitish, and made up chiefly of quartz grains. North of Commerce the sand is gradually modified by the appearance of a partially cemented sandy mud rock alternating with shaly and sandy layers. These gradually thin out about the northern side of the ridge.

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[1] Report on Crowley Ridge. *Geol. Surv. Ark.*, Vol. II. for 1889.

At several places within the area studied there are occurrences of massive beds and isolated blocks of a gray or white quartzite. Shumard cites its occurrence at Commerce, and without referring it to any definite horizon, seems to think it of Lower Silurian age.[1] In volume XIII of the reports of the Missouri Geological Survey it is referred to the Potsdam. A similar rock is described by Call[2] from several localities on Crowley ridge in Arkansas and by him referred to the Tertiary. It is considered by him to be formed by mere local cementation of the sands.

A very little study of the occurrences in Missouri leads to the same conclusion as to their age. They graduate horizontally into the loose sands and are invariably underlain by them. They have not been found anywhere in contact with underlying indurated rocks. The occurrence at Commerce is the nearest to an outcrop of the latter, yet here the loose sands are well exposed beneath the quartzite beds.

The quartzite outcrops as an almost continuous bed from about two and one-half miles north of Bell City to nearly a mile south. (Plate I.) It occurs as a large isolated mass on top of the upland of Crowley ridge, two miles west of Bell City, as thin beds of sandstone on the Bloomfield road, five miles southeast of Leora, four or five miles east of the same place, at Rock Springs church southwest of Dexter, on Bird hill, and at Commerce.

The isolated block west of Bell City is thirty or forty feet long, twenty feet wide, and stands twenty feet above the surface. It represents merely local cementing of the sands, from around which the loose sands have been eroded. At Bell City the absence of these beds in the ravines, back from the ridge front, shows the rapid thinning in this direction. The most massive occurrences are on the eastern slope of Crowley ridge.

The relation of the sands to the overlying gravels is no more certainly known than that of the sands to the underlying clays. The actual contact of an undisturbed locality has not been found. The upper surface, however, of the sand bed was about even when the gravels were deposited.

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[1] *Mo. Geol. Surv.* First and Second Annual Reports, 1855, Part II., p. 156.

[2] *Op. cit.*, p. 99.

The change in character of sediment from sand to gravel is not so great as that from evenly stratified clay to cross-bedded sand. There seems to have been only a short interval with very slight uplift or no interval at all between the deposition of the sands and the gravels. The latter alternative is the more probable.

3. *The Gravels* (*Piketon*)

The gravel bed seems originally to have been spread over the whole region or at least over that part lying south of the Advance lowland. At the present time scattered pebbles are found over the whole area of uplands, but the bed in an undisturbed condition has a very limited distribution. Where undisturbed, it is made up of chert, quartzite, and quartz pebbles mixed with a reddish sand. The latter fills the spaces between the pebbles, but has not been observed to occur in beds. The gravels are distinctly stratified and often show current bedding.

The chert pebbles constitute eighty per cent or possibly more of the pebbles in the bed. They are moderately well rounded, though not sufficiently worn to lose their original angularities. Their rounding is about equal in degree to that of the pebbles in the channels of the larger streams of the Ozarks. They have evidently never been rolled for any considerable length of time on a sea beach. The average size is about that of the South Missouri river pebbles or slightly less, being about an inch and a half in diameter. In character of material they are exactly like the pebbles now found in neighboring Ozark streams. They are composed chiefly of an amorphous, gray, nonfossiliferous chert and were evidently derived from the neighboring cherts of the southeastern slope of the Ozarks after they had been denuded practically to their present level. Further southward they contain a greater proportion, according to Call[1], of fossiliferous pebbles, the fossils being chiefly fragments of Crinoid stems. In this case they were evidently derived from the adjacent Ozark hills in Arkansas, which are made up of Lower Carboniferous cherty limestones. When not bleached since deposition the whole chert and sand mass is of a brownish color.

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[1] *Op. cit.*, p. 120.

The remaining pebbles consist of black, fine-grained quartzite, an occasional reddish quartzite, and white quartz pebbles. They are all thoroughly waterworn and polished. Occasionally one of the dark quartzite pebbles will retain some of its original irregularities, but the quartz and most of the others are thoroughly rounded and have lost all trace of their original shapes. They are entirely unlike any of the pebbles in the neighboring Ozark rivers and show by the wear to which they have been subjected that they have traveled a long distance. Neither the quartz nor any of the quartzite of the kind found in the pebbles is known to occur in Missouri. Quartz veins occur in the Crystalline rocks of South Missouri, but not in sufficient quantity, proportionally, to account for the quartz element of the pebbles even if the excessive wear could be explained. They are evidently of northern origin, coming probably from well toward the northern part of the United States.

The chert and foreign pebbles are intimately mixed in the bed. There is some evidence, however, that the foreign pebbles are concentrated in the lower part of the bed. They are much smaller in size than the chert pebbles. A few have been found which reached an inch in diameter, though the average size is about half that or even less.

At the present time gravels occur scattered over the whole area, though in only a few isolated places in an undisturbed position. The underlying loose sand is so easily eroded that very little of the country stands at its original level. Currents that are able to carry the sands are not able to carry the coarser gravels, so the level is reduced by the washing out of the former, and the latter are left scattered over the surface as occasional pebbles or else as still coherent bodies in inclined positions on the hillsides, and as beds in all the stream channels.

A narrow strip of undisturbed gravel extends along the crest of the ridge from a short distance southeast of Piketon southward to within a mile and a half of Castor river. South of Castor they occur on the divide in a nearly continuous belt to about a mile and a half north of Dexter. From this point to within about two miles of the south line of Stoddard county, they do not occur, except in one or two very small patches about seven miles south of Dexter. In the neighborhood of the county line they stretch along the narrow crest of the ridge for a mile or so. South of this they do not occur again in Missouri.

On the divide between Lick creek and Castor river there is a narrow belt of hills on top of which the gravels occur in patches. North of Piketon the ridge was not examined carefully, though there is a rather high point near Tillman which is probably capped by the bed. The gravels do not seem to occur, except as scattered pebbles, on top of the group of hills in the lowland north of Bell City. They occur in an undisturbed position at a few places on the crest along the south side of Benton ridge. They have not been found in place on Hickory ridge.

North of the Drum and Advance lowland belts the horizon of these gravels has not yet been determined. Gravels occur in isolated patches, but they have not been found in undisturbed position anywhere. They occur most abundantly high up toward the tops of the higher parts of the upland, indicating that their horizon rises northward and that their absence from the northern end of Crowley ridge, Hickory ridge, and possibly also of Benton ridge is due to more vigorous erosion on account of higher original uplift.

A doubtful occurrence in the northwest part of section five, southwest of Bloomfield, indicates that the surface on which the gravels were deposited was lower in the western part of Crowley ridge than elsewhere. The undisturbed condition of the deposit is not clearly evident.

4. *The Loess*

The Loess over this region is a yellowish to brownish clay differing from the typical Loess of the Missouri river valley in being of finer grain and of a more yellowish color.

It occurs over the whole upland area of the region except on the higher points, those that are capped with undisturbed gravel. It has suffered severely from erosion and is cut into valleys and ravines, it has been subjected to land slides and otherwise disturbed and rearranged so that one is never sure that any outcrop is in place. It does not occur, at least as typical Loess, on the hills north of the Advance and Drum lowlands west of Whitewater. Between Whitewater and Drum postoffice the southern edge of these hills is covered with a yellowish clay, which resembles the residual clay of the region more than it does the Loess. This deposit does not occur on the more cherty hills beyond where Castor river enters the Advance lowland. Loess clays are well exposed in the railway cut at Puxico, but they thin westward and disappear near the edge of the lowland west of town. At Poplar Bluff there is no typical Loess. South of that place along the bluffs there is a yellowish clay, but no typical Loess.

The contact between the Loess and the underlying formations is an unconformable one. The gravels and underlying sands were extensively eroded, for the greater part of the upland had been reduced to practically its present condition, except of course those parts which were eroded later in forming the great lowland belts of the region. The gravel beds of Crowley ridge were eroded until they occurred in isolated patches, practically the same as those still existing, and the western part of the ridge was reduced to an undulating plain.

The submergence during the deposition of the Loess included the whole region south of the Ozark hills, except the tops of the gravel caps on Crowley ridge.

5. *The Terrace Loam*

The terrace loam included in the list of geological formations of the region, caps the Sikeston ridge from its southern end to within a few miles of Morley. It is a deposit of sandy brown loam varying from nothing up to twenty-five feet in thickness. It resembles the typical Loess of the Missouri valley and the Loess terraces along that stream and the Mississippi. Its upper surface is about level and is therefore considered to be constructional in origin and later than the Loess. Its youth is shown also by the fact that it was not deposited until the region had been deeply eroded, after the deposition of the Loess. It is underlain by sands similar in character to those making up the southern part of the Benton ridge. The surface on which the loam was deposited was slightly uneven. A few low sand hills project through the surface of the loams, and others rise only to the surface of the latter, producing sandy spots or "sand blows."

This same deposit or a similar one caps some of the low ridges west of Morehouse, but usually as a thin layer.

6. *The Alluvium*

The alluvial deposits of the lowlands have been sufficiently described under the descriptions of the lowland belts. A recapitulation only will be given here.

The Advance lowland belt is underlain by sandy alluvium for a few miles west of the Mississippi river. Gradually this becomes covered westward by a cap of clay which reaches a maximum thickness in the vicinity of, and north of, Delta. West of Delta the clay cap thins and finally disappears at the western side of the "Old Field." Then succeed a few miles of alternating clay ridges and sandy sloughs to the Chalk Bluff road.

Between this and Brownwood the alluvium is sandy, though capped in places by a less sandy loam resembling the terrace loam of the Sikeston ridge. From Brownwood westward and southwestward the clayey alluvium is continuous, except on the few low sandy islands described above (page 6).

The Morehouse lowland is underlain by sandy alluvium, except in the neighborhood of the Whitewater and Castor rivers where the sand is capped by a layer of clay.

The alluvium of the Mississippi flood plain or the Charleston lowland is all sandy like the alluvium of that stream everywhere south of the mouth of the Missouri.

C. GEOLOGICAL HISTORY OF THE REGION

The geological history of the region, so far as it is recorded in the rocks now outcropping in it, opens with the deposition of the Ozark limestones of probable Lower Silurian age. This phase of the region's history continued without any important break through the Trenton and with great probability also through Upper Silurian time. With less probability it continued through Devonian times and may possibly have ended after Carboniferous times, closing with the folding of the Appalachians and their trans-Mississippi extension or representatives, the Ouachita mountains of Arkansas. This long period of deposition was followed by a long period during which these rocks were uplifted and profoundly eroded. Then followed a second submergence and the deposition of the Tertiary shales and clays, followed by a second uplift and period of erosion, which, however, was not of so long duration as the first. A third submergence followed, and the Lafayette sands and clays were deposited, followed, with very short if any interval, by the deposition of the Lafayette gravel bed. A third uplift followed, during and after which the previously deposited beds were greatly eroded, the gravel bed disappearing from the whole area, except a few isolated patches. A fourth depression followed, and the mantle of Loess was deposited over the uneven surface, filling the valleys and building the land up nearly to its level before the preceding erosion. Then followed uplift and erosion to the present condition of the country. During the last stage in the history of the region slight oscillations have occurred producing terraces, but they were not sufficient in amplitude to interrupt the continuity of the cycle.

A tabular statement of the foregoing is as follows, beginning with the lowest phase:

1. Deposition of Palaeozoic limestones.
2. Erosion interval.
3. Deposition of the Tertiary clays.
4. Erosion interval.
5. Deposition of Lafayette sands.

6. Erosion interval (?).
7. Deposition of Lafayette gravels.
8. Erosion interval.
9. Deposition of Loess.
10. Erosion interval.
11. Deposition of terrace deposits.
12. Erosion interval still in progress.

D. GEOLOGICAL STRUCTURE

The structure of the region is extremely simple. The Palaeozoic beds dip southeastward at a low angle and without folding. The younger beds have a very slight southward dip. The dip of the Palaeozoic beds is a result of deformation, that of the younger beds, probably of deposition only.

PART II. EXPLANATION OF PHENOMENA

CHAPTER III

THEORIES OF LOWLAND FORMATION.

1. *General Statement*

The existence of such a large area of flat land, its distribution in broad continuous belts with sharp steep slopes on both sides, and its sudden expansion from the much narrower belt of flat Mississippi river bottom at Cape Girardeau, have attracted a great deal of attention ever since the first occupation of the region by white men. The fact that these belts are not followed continuously by any stream and are not even crossed by streams large enough to be referred to as the cause of the lowland belts, has further increased this interest. They are like river valleys, but the rivers cross them rather than follow them. The whole area has always been considered as one that was separate and distinct from any other part of the State—as an area unique in itself. Because of the large area of undrained or poorly drained land in these belts the whole region is familiarly known as the swamps of southeastern Missouri. The description here given shows, however, that they are not swamps like the areas of water-soaked or liquid vegetable matter occurring in northern latitudes. They are mere bottom lands, in which the sandy alluvium may be reached anywhere, under but a very few inches of rotten leaves and twigs. The inhabitants of the area have sought their own explanations of the facts, though they are not based on a comprehensive view of the whole area and the relations of the various parts to each other, nor often on a detailed study of the facts in any locality.

The Mississippi river is the most powerful continuously operating force within the experience of the inhabitants. They regard the lowlands, therefore, as in some way the product of the action of the Mississippi river, or rather they consider the lowlands as old valleys of that river. With many of them a second factor enters into the reckoning, namely, the earthquake shocks of 1811 and 1812. A large part of the area is supposed to have sunk at that time, though the amount of sinking has not been agreed upon. The relative effect of these two forces has never been clearly determined by even the most strenuous advocates of the earthquake's effectiveness.

The theory most often encountered among those who do not give the earthquake hypothesis much credit, is about as follows: At some time in the past, the Mississippi river was much larger than it is at present. On reaching the northern border of the coastal plain at Cape Girardeau it separated into several branches or distributaries, among which three were by far the largest. One of these turned westward and southwestward by the way of the Advance lowland, another turned southward from the latter by way of the Morehouse branch of the Cairo lowland, and the third turned slightly southeastward by way of the existing channel of the Mississippi. These, however, were the courses of the main channels of the stream only, and in exceptionally high water stages the whole area was submerged. The river under such conditions was heavily loaded. It deposited sand, forming sandbars then as now, between the main current lines. Crowley ridge, Bird, Lost, Cow, and Ringer hills, and Benton ridge are some of these sandbars that were deposited in this flooding river. Later the volume of the river diminished, and in shrinking to its existing dimensions it abandoned all the channels except the one by Commerce.

A fatal objecton to this theory is the fact that the beds of rock, making up Crowley, Benton, and the other ridges and hills, are fragments of beds that were once continuous over the whole intervening area between the ridges, and have been removed by erosion in the lowland belts since their deposition—when Crowley ridge was formed the whole county was built up to its level, the lowland areas as well as the ridges. The beds making up these ridges are of widely different ages, with intervals between the times of the formation of some of the contiguous beds that are far greater than the whole time that has elapsed since the birth of the Mississippi river. The beds in sand bars never had any greater extent than the area of the sand bar. They are all of the same geological age also. The material of which these hills and ridges are built is widely different as a whole from that of river sand bars. There are beds of solid limestone, pure sand, black clay, coarse gravels, and loam—all of considerable thickness and evenly distributed in layers, not mixed together.

2. *Literature*

Three interpretations based in each case on imperfect knowledge of the facts have been given in scientific literature. Two of these are mere statements of the succession of events, that were supposed to have taken place, without an account of the facts or the arguments supporting the statements. They are incidental statements in a literature that is concerned chiefly with other subjects. One of these is by Branner,[1] the other is by Call.[2] The third interpretation is one advanced by the writer several years ago,[3] and was based on the facts that were available at the time.

Branner's statement is as follows: "The Mississippi river, instead of having always cut through the solid rock as it now does southeast of Cape Girardeau, formerly flowed west of Crowley ridge, having a southwest direction at Cape Girardeau and flowing through the lowlands. It flowed past Delta, Poplar Bluff, and Neelysville, and joined the Ohio somewhere south of Helena; subsequently it cut through Crowley ridge at Chalk Bluff and flowed down the St. Francis valley, and still later it cut the ridge between Bloomfield and Benton, Missouri, and joined the Ohio south of

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[1] Report on Crowley Ridge. *Geol. Surv. Ark.*, Vol. II. for 1889, p. XIV.

[2] Report on Crowley Ridge. *Geol. Surv. Ark.*, Vol. II. for 1889, p, 128.

[3] Boston Society of Natural History, Vol. XXVI, p. 479.

New Madrid..... While the Mississippi flowed through the Arkansas valley to the east of the ridge, the Ohio was washing down similar beds on its opposite side, and it was not until towards the close of the glacial epoch that the old channel southwest of Cape Girardeau was filled up and the Mississippi cut through the hills to the southeast and joined the Ohio at Cairo."

The outline presented by Mr. Call is a much longer one, and is based on a study of the geology and topography of Crowley ridge in Arkansas. It includes the geological as well as topographical history of the region since the beginning of Tertiary time, and in a much abridged form is about as follows: (1) Deposition of the Tertiary clays. (2) Uplift and erosion of valleys by the Mississippi river. The river separated into two main channels just south of Cape Girardeau, one running east, the other west of what is now Crowley ridge. The lowland described in this paper as the Advance lowland was eroded at this time. The Mississippi finally abandoned the valley west of the ridge and flowed east of it. (3) Depression and deposition of the Tertiary sands by currents which flowed along the shores of the new gulf. (4) Elevation and erosion of the sands. The harder parts of the bed were left as a long series of hills not much above the level of the surrounding country. (5) Submergence and the deposition of a bed of gravel. (6) Elevation, but no statement as to the extent of erosion taking place as a result of this elevation. (7) Submergence and deposition, first deposition of glacial age in the region. (8) Uplift and erosion of the great trench of the modern Mississippi. (9) Later glacial submergence, or at least a period of deposition during which the Mississippi trench was partly filled. (10) Partial excavation of the trench of the Mississippi.

The third interpretation referred to above was offered in 1895 by the writer and was based on a study of the geological and topographic literature and maps of the region then in existence. For that part of the region included in this report, the part in which the origin of the phenomena must be sought, there was neither literature nor maps except an extremely imperfect geological map issued by the Geological Survey of Missouri. No sort of topographic map of this part of the lowlands was in existence.

The interpretation was based therefore chiefly on Call's maps and report cited above, and on the general map issued by the Mississippi River Commission.

According to these maps the main lowland belt that is not now followed by a large stream, the Advance lowland, lay along the border between the coastal plain deposits on the one hand and the Palaeozoic highlands on the other. None of the coastal plain deposits were shown north or west of this lowland, and none of the Palaeozoic south or east of it, except two ill-defined patches, one just north of Commerce and another near Puxico. Nothing was known of the shape of the floor or of the sides of that part of this lowland lying north of the Missouri-Arkansas state line. The Morehouse branch of the Cairo lowland and the gorge above Commerce were not considered important factors, since their features were not known. On the basis of such facts as could be determined the Advance lowland was explained as an inner lowland, developed by the combined erosion of small tributaries of many transverse streams, along the strike of soft rocks, in the usual manner in which such lowlands are developed, for example, like the lowland belt along the inner border of the Atlantic coastal plain between Philadelphia and Cape Cod. It was, in fact, considered a part of this same lowland belt, occupying as it does a homologous position. Crowley ridge was considered a *cuesta,* the eastern part of whose structural plain had been eroded away by the Mississippi river. That river, however, it was thought, had had nothing whatever to do with the excavation of this lowland belt.

The statement made by Dr. Branner is no attempt to prove that the events recorded actually took place, much less to show how they were produced. It is, in fact, merely a statement of the popular view and lays no claim to scientific completeness. It is, as will be seen further on, chiefly the same as the interpretation of the phenomena given in this paper.

The explanation offered by Mr. Call is more than an expression of the popular view. It is an attempt to interpret the phenomena on the basis of facts observed in the study of the locality. It claims credit as a scientific generalization based on facts gathered at first hand by the author. There are, however, several serious difficulties in the explanation offered. The order of events can not have taken place as outlined by him. The chief difficulty and one wholly irreconcilable with the facts, is the placing of the erosion of the Advance lowland belt prior to the deposition of the Tertiary sands and gravels and of the Loess. Had this order of events taken place, the lowland would have been completely filled by these deposits. The maps accompanying this paper show conclusively that the Loess, gravel, sand, and clay were all cut alike by the force which eroded the lowland. The whole series of lowland belts is younger than the Loess. There is nothing known of the pre-glacial topography of the region, except that the western part of the lowland region was then a lowland; but that was filled by the Loess, and the existing lowland belt excavated in that and the underlying rocks. The paper makes no attempt to show the method by which the river abandoned an old course and adopted a new one across a former divide.

The study of the region since the publication of the third interpretation referred to above has shown that the position there taken is, so far as its application to this region is concerned, wholly untenable. The Advance lowland is not an inner lowland, Crowley ridge is not a *cuesta*, the transverse drainage of the Advance lowland is a very recently established condition, and the Mississippi river has very recently occupied the gorge between Grays Point and Commerce. With accurate geological and topographic maps at hand it would not have been difficult, by the method adopted in the preparation of that paper, to have discovered the origin of the Advance lowland and possibly of the others also; but to have determined the whole succession of events and the processes operating to produce them would have been more difficult and probably impossible by the methods of library study alone.

The geology and topography of the Advance lowland could not have attained their existing status except through the operation of a force that was continuous and of essentially equal intensity throughout the whole length of its course. The width of the belt varies, but is in perfect sympathy with the depth and character of rock removed. The floor of the lowland is not uneven like the surface of coastal plain lowlands, but is flat, and the highlands on either side drop to the lowland level in steep bluffs.

The same statement as to unity may be made concerning the Cairo lowland. The uniform trend of the bluffs bordering its northern side from east of Commerce westward and southward to the south line of the area, could have been produced only by one force that was operative along the whole line of bluffs continuously, simultaneously, and with uniform strength. The forces producing the two subdivisional lowlands of this belt operated in a north-south direction and therefore across the trend of the force producing the main lowland. These forces have not modified the Cairo lowland so far as its area or boundaries are concerned. They have merely deepened certain parts of it.

3. *Possible Processes Producing the Lowland Belts*

Geographers are familiar with three processes that produce lowland belts under the proper conditions. They are: First, subsequent erosion by the small tributaries of larger streams which flow across the outcrop of a series of beds of soft rocks; second, parallel faulting and the collapse of narrow strips between adjacent faults; third, erosion, by rivers and creeks, and subsequent abandonment of their valleys.

The application of the first process to the lowlands of southeastern Missouri has been shown above to be untenable. It needs no further discussion here.

The second process is well known to have operated in many places over the earth's surface, particularly in Europe. The Rhine lowland between Bingen and Basel is due to this process, and so also is Das Ries, a somewhat circular area in the eastern part of the Jurassic plateau of South Germany. The Germans name such features *gräben*. In such cases the top formation in the floor of the lowland is the same as the top formation on the adjacent uplands. Erosion subsequent to the faulting would certainly remove it from the uplands and cover it in the lowlands with debris from the adjacent uplands, but in the case we are considering there has been no significant erosion of the uplands nor filling of the lowlands since the lowlands were formed. There has not even been time for the formation of any considerable amount of talus at the foot of the cliffs. The surface of the lowland would duplicate, also, in details of relief, that of the adjacent uplands. Except in case of an extremely uniform amount of faulting, the general level or slope of the lowland would not be uniform. Boring also beneath the surface of the lowland would reveal the same succession of formations as were exposed in the edges of the fault scarps.

The phenomena of the lowland belts fail to agree with the scheme of necessary consequences as outlined above, not only as a whole, but they fail to agree in any single instance The lowland surfaces slope uniformly in one direction. They do not agree with the uplands in details of relief, for they have very little detail, nor in the succession of formations downward.

The third possibility is the only one left. By the method of exclusion we should be able to prove that these lowlands are old river valleys if we could show that we had exhausted all the possibilities. This would probably be more difficult to prove than to find additional evidence to add to this which will show that the lowlands are river valleys. Such evidence is abundant and conclusive.

(1) The width of river valleys, after the streams have passed the earliest stages of youth, is in sympathy with the hardness of the rock in which the valley has been cut, and with the relative thickness of the hard and soft beds which were cut through at any point. The Advance lowland meets both these conditions perfectly. South of where the St. Francis river enters it the lowland is wide, and the rocks which were removed were soft sands and clays. North and east of this the rocks in the lower parts of the bluffs on both sides of the belt are hard, but the thickness of hard rock cut is greatest exactly there where the valley is narrowest—west of Puxico.

(2) The trend also of river bluffs is characteristic. They do not often follow a straight line for any great distance, but the deviation from such a line is gradual. They are disposed in long swinging curves, and their line of trend is a smooth one if not straight. The topographic map accompanying this paper shows that the bluffs of the Advance lowland possess this character in a high degree. The curves between Rock Levee and Whitewater and between Greenbrier and Wappapello are good illustrations.

The curve of the Cairo lowland from Commerce by way of Benton, Idalia, and Dexter to the south line of the map is another good illustration.[1]

(3) Cross profiles of the lowlands are typical profiles of mature river valleys. The bluffs on each side are steep, and the plane of their slopes makes a sharp angle with the plane of the valley floor. The cross-profile line of the floor is level.

(4) The deposits underlying the floor are typical alluvial deposits, not uniform everywhere, but the variations are easily explained.

(5) The longitudinal profile of the lowland floors shows a persistently uniform slope southward, at about the rate of the flood plain of large heavily loaded rivers.

(6) The lowlands are continuous with the existing valleys of the Mississippi and Ohio rivers and their widths and shapes agree with them.

The features of the lowlands and their relation to the neighboring river valleys furnish unmistakable proof that they are old river valleys that have been abandoned (except the Charleston lowland) by the rivers that eroded them.

4. *Age of the Lowlands*

All the formations, except the alluvium, were eroded by the streams which formed the lowlands. They are, therefore, younger than the Loess. Chamberlain and Salisbury have shown that the gorges of the large rivers of the central part of the United States were eroded in the interval between the first and second glacial epochs. These valleys are presumably of the same date, since it is extremely improbable that they should have been eroded for this small area alone. They are also demonstrably of the same or later age than the gorge of the Mississippi above Cape Girardeau, which, according to the authorities cited, is of interglacial age. This interpretation agrees also with the relation of the valleys to the geological formations of the region. The Loess, a deposit of Pleistocene or glacial age, occupies the same position, with one doubtful exception, with respect to the valleys, as do the older formations. All were excavated alike. There were valleys in existence immediately preceding the Loess deposition, but they were not the great valleys here discussed. The evidence is clear that the western part of what is now Crowley ridge was well worn down before the deposition of the Loess, but the significant fact is that the Loess is the surface formation over all this low region while it is not the surface formation in the lowlands.

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[1] The notch in the east side of Crowley ridge at Zeta is not a part of this curve. It is a part of the broad gap lying between Benton and Crowley ridges and was formed after the formation of the northern and western curving border of the Cairo lowlands and by a different eroding agent. It was formed by the stream that eroded the belt connecting the Morehouse and Advance lowland belts.

It has not been identified beneath the alluvium in the few borings that have been made in the lowlands. A mile south of Lakeville there is a slightly undulating strip lying north of the steep bluff of Palaeozoic rock forming the southern boundary of the lowland, which is composed of a Loess-like clay though more like the terrace deposits of Sikeston ridge than the Loess of the adjacent uplands. The surface of this strip of country does not rise more than twenty feet above the sandy alluvium of the lowland in the vicinity of Advance. While no wholly satisfactory explanation of the existence of this strip has been reached, yet the evidence elsewhere of the post-Loess age of the valleys is considered as sufficient to warrant a corresponding conclusion here, with the recognition of the fact that more careful study of the region may modify it slightly. One thing is certain, the lowlands were *occupied* by large rivers after the deposition of the Loess. Professor Salisbury[1] places the deposition of the Loess of the region in the second episode of the first glacial epoch.

The valleys were eroded much deeper than at present and later filled by deposition of alluvium. The filling, which was a phenomenon extending over a large part of the Mississippi valley region, took place, according to Chamberlain, during the second glacial epoch. The coarse, sandy character of the filling in these valleys accords with this view. It differs from modern alluvium of the region in both these respects.

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[1] Report on Crowley Ridge. Annual Report for 1889, Vol. II, p. 23.

As will be shown later, the various lowlands are not of the same age. This statement can hardly need proof. A slight knowledge of river life will satisfy anyone that, although rivers may spread out into several channels when young, they do not continue in this condition to maturity, the stage reached in these valleys before they were abandoned.

The Advance and Cairo belts are contemporaneous. The modification of the western half of the Cairo belt and the erosion of the broad belt of lowland between Crowley and Benton ridges, forming the Morehouse lowland, were produced later, while the Charleston lowland has never been abandoned. The Duck creek lowland was probably formed while the Advance and Cairo belts were being eroded.

5. *The Eroding Agent*

The stream or streams which eroded the lowlands were the streams that now drain the region. They are so recent in age that no complete rearrangement of drainage can have taken place since their erosion. If rearrangement had taken place, it would not have been confined to the area of the lowlands, but would have reached over a large part of the Mississippi valley. There is absolutely no evidence for such rearrangement. These lowlands must have been eroded either by the Mississippi and Ohio and then abandoned by them, or else by the smaller streams such as Whitewater, Crooked Creek, Castor, St. Francis or Black rivers. The arguments against the latter alternative are abundant and conclusive. An important one is that these streams are wholly incompetent. Their valleys, where they open out into the Advance lowland, are less than a mile in width. Whitewater and Castor open into this lowland where it is several times as wide as the width of their combined valleys and excavated in exactly the same kind of rock. The same is true of the St. Francis and Black. A short distance south of where they enter, however, the character of the material excavated changes materially. This does not affect the valley at the points of entrance. The material carried by these rivers is entirely different from that which is deposited in the main valleys. These rivers drain a region that was not invaded by the ice during glacial times, so that the material they have carried since the cutting of their valleys has not changed materially. The main lowland has an entirely different trend, also from that of the valleys of the small rivers. They enter it at right angles to its trend. Furthermore, the Advance lowland is continuous from the existing valley of the Mississippi and of such uniform width and shows so complete an absence of cuspate bluffs that it could not have been produced by the coalescence of the valleys of several southwardly flowing streams. The same arguments apply to the Cairo lowland as well.

The Advance lowland was eroded by the Mississippi river and the Cairo lowland by the Ohio. The former is continuous with and of accordant width with the Mississippi trough above Cape Girardeau. Its course at its eastern end is part of a curve that commences in the Mississippi bluffs above and on the opposite side from Cape Girardeau. The existing channel of the Mississippi leaves the valley in a course at right angles with it at Grays Point, about the middle of this curve, but the gap is not wide enough to break the evident continuity of the bluff-curve crossing it.

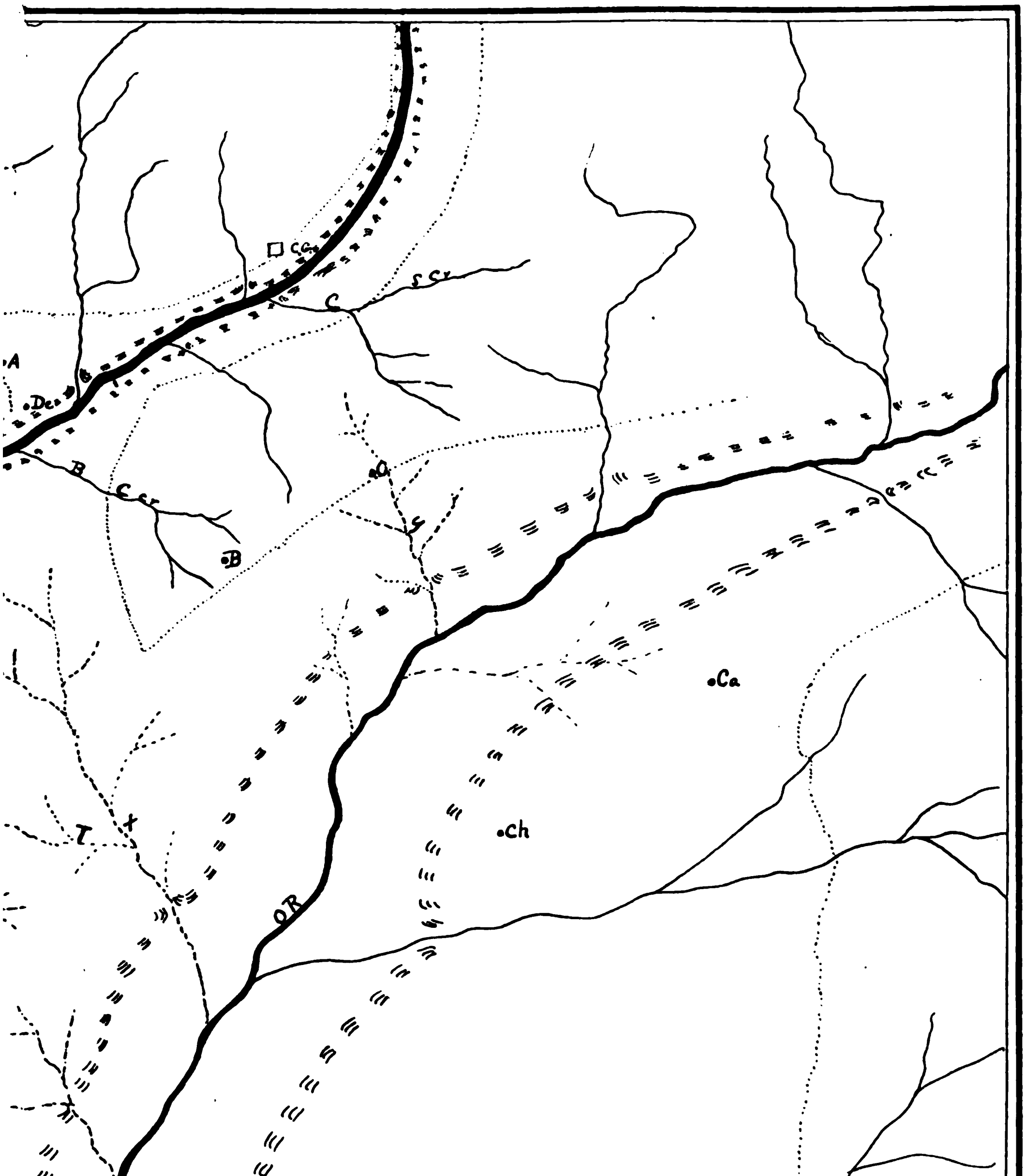
The bluffs of the Cairo lowland are continuous with those of the valley of the Ohio above its existing mouth and have no corresponding relation with the Mississippi bluffs. The southern end of the Benton ridge is continuous with and in line with the southern end of the upland of southern Illinois east of Commerce. The Mississippi here crosses this bluff line at right angles. The Cairo lowland from Commerce southward and southwestward is the valley of the Ohio river, which has been invaded recently by the Mississippi. It has been changed slightly since the invasion, but only in a comparatively narrow belt. The Ohio continues to flow, therefore, in its original valley.

The formation of the Morehouse lowland belt by slightly deepening the western side of the Cairo belt, and the erosion of the

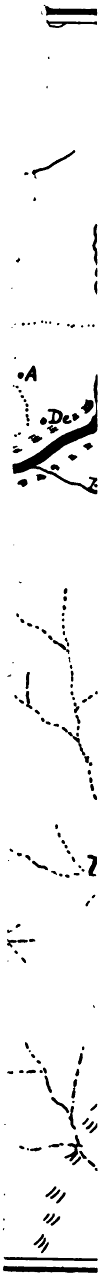
broad belt connecting it with the Advance belt, were accomplished by the Mississippi river after it had abandoned the western part of the Advance lowland, and before it adopted its existing course from Grays Point by Commerce to New Madrid.

The Mississippi river, therefore, originally turned westward at Cape Girardeau and followed the course now occupied by the Advance lowland belt. While it occupied this course, the Ohio was
at work eroding the Cairo lowland. The
wholly in loose sands and clays while the Mis
in hard limestones. The Ohio, therefore, wa
to erode a much wider valley than the Mis
time Crowley and Benton ridges formed a
drainage divide, extending from Helena,
into the uplands of Illinois. Subsequently
abandoned the western part of the Advance l
way southward from where Delta now stand
Ohio. At a still later period it abandoned this
its existing course from Grays Point into the
merce.

PLATE No. IV.

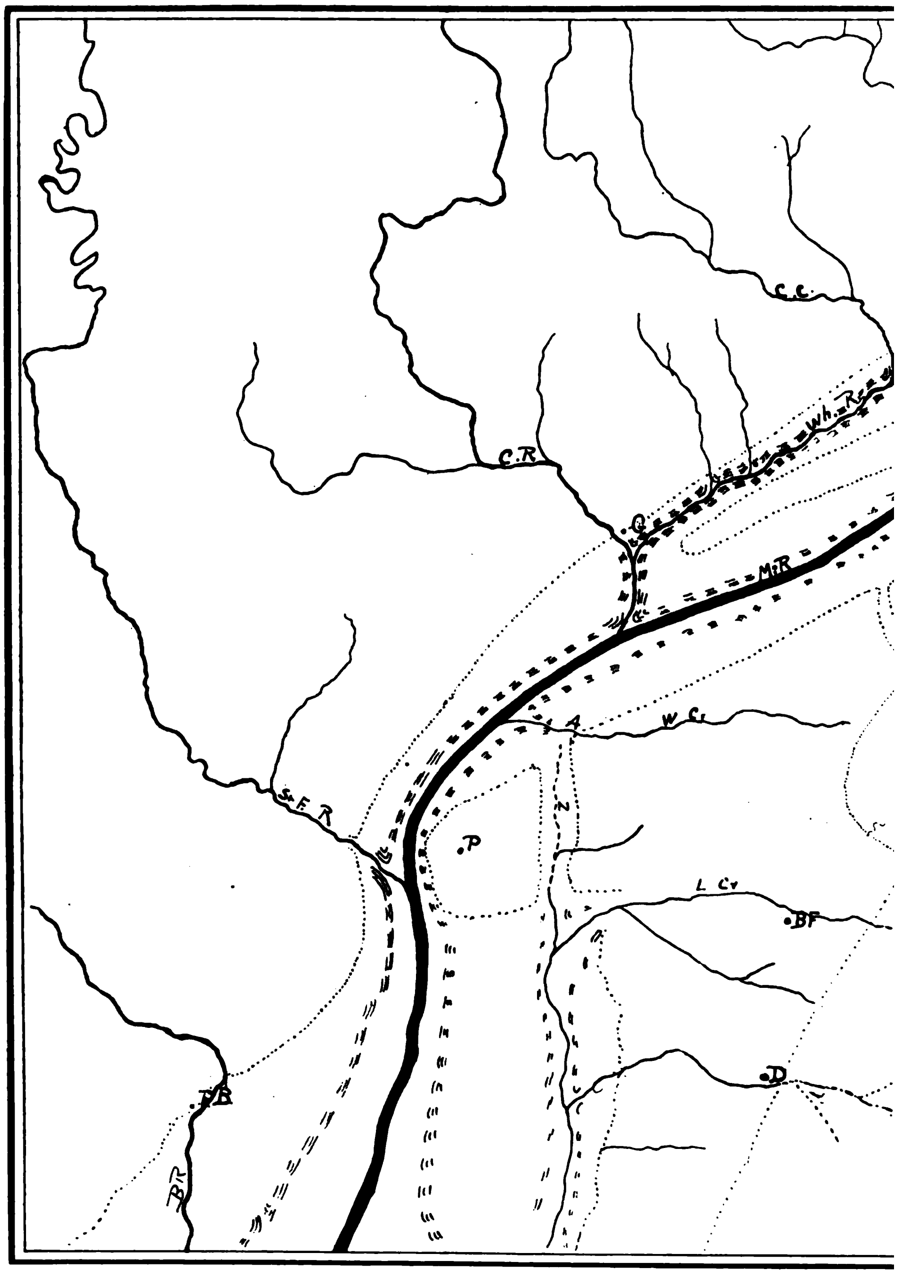


ardeau; Ca.=Cairo; D.=Dexter; B.F.=Bloomfield; P.B.=Poplar Bluff; B.=Benton.



'ardeau

University of Missouri Studies, Vol. I, No. 3.



Drainage of the region before any captures had taken place. C.G.=C

CHAPTER IV

ORIGIN OF SOUTHEAST MISSOURI LOWLANDS

The Mississippi river has abandoned two valleys and now occupies a third. This is a case, therefore, of the abandonment by a large stream of a part of its valley in favor of that of a smaller stream. The Mississippi has been captured by the Ohio twice in succession.

1. *General Processes of River Capture*

The process by which rivers entrench themselves is well understood. The shifting of channel made by a mature stream in a broad flood plain is a matter of common occurrence on the flood plains of large streams. The change, however, by which a river shifts, not merely its channel, but its whole course, abandoning a part of its valley and acquiring a new one, is not so common an occurrence. Rivers, after having once entrenched themselves, can not readily get out of their trench. They can not lift themselves unaided over the valley sides. This is especially the case with large streams. Change of valley by small streams in favor of that of a larger one is a phenomenon familiar to all geographers and geologists who have devoted any attention to the processes of geographical development. The whole subject of river piracy concerns itself with this process. The capture of a large stream by a smaller one is, however, a phenomenon not so well known. River captures usually take place in mountainous regions and in localities where the rocks have been extensively folded, and where there are widely varying resistances in the rocks of a small area. Stage in cycle also has been considered an important factor, it being generally agreed that river capture takes place more often during the early part of the second cycle of development than at any other time.

None of these conditions obtains, in the region under discussion, except possibly the last one, and in order that it may be effective the others must be presupposed. The rocks are not folded, and they are all of about uniform resistance. Furthermore, in this region the capture, or change of valley, call it capture or not, took place long after the river had reached grade. It had also aggraded its valley many feet after reaching grade, before it finally abandoned it. Captures of the kind above referred to, taking place in mountainous regions, usually occur before the captured stream has reached grade.

The occurrence of a kind of stream capture, after the captured stream has reached grade, has been described from a few places in Missouri.[1] It was brought about by the lateral sapping of two adjacent streams, thus cutting through the upland separating them. The only cases where the process has been observed have been due to the sapping on the convex sides of meanders in streams strongly characterized by such, and the stretch of valley abandoned is only a very few miles. The length of valley abandoned by the first change of the Mississippi is more than two hundred miles, and by the second about fifty miles. Furthermore, in such cases, the two valleys must become confluent at the point of capture, and the upland must be reduced to cusps on each side of the gap. The width of the neck of upland through which the changes in the Mississippi were made was in the last case about eight miles, and in the first about the same of high land, though there was a much longer strip of lowland beyond the high belt.

Another process, a slight modification of the last one, was described in the paper referred to above and was considered as having operated in the last change of the valley of the Moreau river, near Jefferson City, Missouri. The valleys of two large streams are separated by a narrow belt of upland. A small stream flows into one of them, heading on the upland between the two main streams. That one of the larger streams into which the small stream does not flow, saps the bluff on the side nearest the other large stream, gradually working toward the head of the small tributary. By continued sapping it finally cuts off the head of the tributary, then continuing cuts off more and more of it, reaching a lower and lower level of its valley, thus deepening the gap between its valley and that of the other large stream. It finally reaches a point where it can shorten its course by flowing into the other stream through the beheaded trunk valley of the tributary, abandoning the lower part of its own valley. In the case cited the captured stream or the stream which made the change of course, was the smaller stream. The course through the ridge was a more advantageous one on account of the lower level of the larger stream.

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[1] *Cote Sans Dessein and Grand Tower. Am. Geol.,* Feb. 1898.

The largest stream within an area does not always have the lowest valley floor, especially when both streams are very large and drain regions of varying climatic and geological character. The Missouri river flood plain, for example, is about 750 feet above sea level at Kansas City, a distance of about 275 miles above its mouth, while the Mississippi flood plain at Burlington, Iowa, about an equal distance above the junction of the two streams, is only about 545 feet above sea level, 200 feet lower than the Missouri. Yet the Missouri is the larger stream. If these valleys lay within ten miles of each other at this distance above their mouths, the temptation for the Missouri to get into the valley of the Mississippi would be very great. The stream which carries the heavy load is the one that is held up on a high level, as compared with that of the one with a small load or with a load of finely divided material.

2. *Conditions Favoring Capture in Southeastern Missouri*

Both the Mississippi and Ohio rivers are large streams and drain areas of greatly varying geological and climatic characters. At the present time the Mississippi carries much the larger load of material and also material that is much coarser than that carried by the Ohio. They have both reached grade, yet each has graded itself in accordance with the amount and character of load it carries. The Mississippi, therefore, has a steeper grade than the Ohio. The elevation of the Mississippi flood plain at Cape Girardeau is about 340 feet above sea level, and at St. Louis it is about 425 feet. The Ohio flood plain at Cairo is about 315, and at Evansville, Indiana, about equally distant, about 365 feet above sea level. In one case there is a difference in level between the two places of eighty-five feet, in the other of fifty feet.

The distance from Cape Girardeau to Helena, Arkansas, where the Mississippi originally flowed into the Ohio is a little more than twice as far as that from Cape Girardeau to St. Louis. If the same relation held originally as now, there was in the neighborhood of Cape Girardeau, before the change of course by the Mississippi, a difference in level of about sixty feet. It can not be demonstrated, very probably, that this relation did obtain or has obtained at all times, for during the maximum extension of the ice during the second glacial epoch both streams were avenues of discharge for a large amount of glacial waste. The ice disappeared from the drainage basin of the Ohio much earlier than it did from that of the Mississippi, and the former was able, therefore, to do some work toward adjusting its grade to existing conditions before the Mississippi was relieved of its burden of ice ground material. The Mississippi, however, has never been relieved of the burdensome load that is dumped into it by the Missouri, so that the change of grade that took place on the Mississippi was not so great as that on the Ohio after the retreat of the ice. On the other hand, if the change of course took place soon after the second glacial period, this readjustment was not an important factor. Allowing a considerable margin for the unknown factors, it seems quite evident that there was a difference of level of several feet in the two valleys at the southeastern corner of what is now the State of Missouri, at the time of capture, giving considerable inducement to the Mississippi to take advantage of all opportunities to abandon its own valley and occupy that of the Ohio.

3. *Methods of Capture in Southeastern Missouri*

The last process described above is the one that has operated in the region under consideration. The captures took place as a result of the varying degrees of hardness, though this did not retard the captured stream. The Mississippi, the captured stream, eroded its valley in hard rock, the Ohio, the capturing stream, in soft rock.

The Mississippi, however, was not held at a higher level than the Ohio, thus making capture possible, because of the nature of the rock. The capture did not take place until the Mississippi had reached a grade determined wholly by other factors than the hard rocks in which it had cut its valley. It had not only reached grade, but it had opened a valley three to five miles wide, and had then aggraded it at least a hundred feet. It was only indirectly, through its influence on the development of the minor drainage, that hardness of rock affected the hydrographic status in the lowland region.

The minor drainage of the whole of what is now Crowley and Benton ridges and apparently of the belt between them, was originally westward or northwestward. The divide between the Ohio and the Mississippi in the early stages of their development lay east of the present eastern side of Crowley ridge. All the larger streams now draining Crowley ridge have been beheaded by the widening of the Cairo lowland. This was done before the first capture of the Mississippi took place. It has been shown already that the Mississippi river has had nothing to do with the fashioning of the eastern bluff of Crowley ridge, south of Bell City, and of the south side of Benton ridge. The Ohio dealt with soft rocks and could open out a wide valley.

While the Ohio was opening this belt and the Mississippi was opening out the Advance lowland, Caney creek flowed northwestward into the Mississippi. Throughout its lower course it had to cut the hard limestones of the Ozark series. Valley deepening under such conditions was rather slow, so that the middle part of its course, although flowing over the soft sands of the Tertiary, was held well above the level of the Mississippi flood plain and still farther above that of the Ohio to the south. The hard limestones, however, dipped beneath the level of the Mississippi flood plain, entirely out of the way of small streams, only a very few miles south of the river. It was only the lower course of Caney creek that had to cut hard rock. A small stream (X, Plate IV), growing headward from the Ohio flood plain, at some point between the present position of Morley and Cow hill, had no such difficulty to contend with. It grew rapidly both on account of the rock in which it worked and of its short steep course. Growing backward nearly at right angles to the course of Caney creek, it succeeded in tapping the latter above where it entered the hard rock and in offering it a course which avoided that difficulty. Thus strengthened it was able to deepen rapidly the upper part of the Caney creek valley. On account of the lower level of the Ohio flood plain the pirate was able soon to sink its valley, at the point of capture, to a level as low as that of the Mississippi. Although the tapping may have taken place north of the line of disappearance below its grade-level of the hard bed, yet there was so thin a layer of that to be cut that the work was soon done. Plate V is an attempt to map the drainage of the region as it existed about this time.

The slope of this valley, southward from the point of capture, was greater than the slope of the valley of the Mississippi. It was in position, therefore, to offer to that stream a steeper and shorter course than it possessed, provided the Mississippi could gain access to it. This was effected by the sapping of the ridge between the Mississippi valley and that of the captured stream. The curve in the Advance lowland, between Advance and a point a few miles above Cape Girardeau, is such that a vigorous stream, flowing in it southwestward, would sap its southern bluff. The Mississippi, while still occupying the Advance lowland, gradually pushed its southern bluffs backward until it finally cut into the valley of the diverted Caney creek, and immediately occupied it.

The date of the capture and abandonment can not be fixed nearer than to say that it took place after the close of the first glacial epoch. There has been some boring in the bottom lands, but the results are not sufficient to enable one to fix the date of capture more closely by means of correlating the filling of the valleys here with the same events elsewhere in the country. The Advance lowland seems to have been originally deeper than now and later aggraded, before the Mississippi abandoned it. Throughout its whole extent the undoubted Mississippi river sandy alluvium is encountered either on the surface or within a depth of twenty feet.

4. *Capture of Wolf Creek*

Wolf creek, which flows into Castor river near Leora, was originally one of the westwardly flowing tributaries of the Mississippi. It entered the latter stream somewhere in what is now the Advance lowland, through the existing valley of Castor river west of Leora, probably a little north and west of the position of Headquarters. Like Caney creek its middle and upper parts were in soft rock, and its lower course in hard rock. It entered the latter near where Leora now stands. While Caney creek was being tapped by stream X (Plate IV), Wolf creek was being treated in a similar way by stream Z.

In this case the advantage arose wholly from the difference in character of rock. Stream Z grew headward from Lick creek, which was a tributary of the Mississippi river and not of the Ohio, as was X. Z had only a short distance to work, however, in order to reach Wolf creek, and effected the capture early. Wolf creek became then a tributary of Lick creek, which it reached through what is now the Duck creek lowland belt. By the energy of the enlarged stream this belt was eroded. While it was being done the Mississippi, by sapping the southern side of its valley, approached nearer and nearer to the Wolf creek valley at the point of capture. It finally cut into it, but since Wolf creek was itself a tributary of the Mississippi, its valley could not be lower, nor even so low as that of the latter, so it could offer no more advantageous course to the master stream. Instead, therefore, of the Mississippi being captured, it recaptured from Lick creek its former tributary, Wolf creek. Duck creek lowland is, therefore, not an old valley of the Mississippi nor of Castor, but of Wolf creek. During all this time Castor river flowed into the Mississippi. This capture of one of the original westwardly flowing streams is probably the first one that took place, and the cutting into the enlarged valley of the captured stream certainly took place before the capture of the Mississippi by the Ohio river through X creek.

5. *The Mississippi and Whitewater Rivers*

Whitewater river, after its junction with Crooked creek near the locality of the town of Whitewater, flowed westward through the Drum lowland belt and joined the Mississippi in the vicinity of Greenbrier. After having reached grade, its load was rather light, so its slope was not great. It flowed in a valley excavated from end to end in the resistent Ozark limestones. It could not be reached by headward growth of a stream working on soft rocks, because there were no such beds north of the Mississippi. The northward curve of the bluffs west of Cape Girardeau indicates that the Mississippi river for some time before its capture, was turned toward the northern side of its valley. The corresponding curve in the north bluff of Benton ridge indicates the same thing. The Mississippi seems, therefore, to have swung southward past the locality of Cape Girardeau, sapping the eastern side of the valley, then southwestward to near the locality of Kelso, then it was deflected across the valley to the northern bluffs. It worked westward by sapping, soon cutting a notch which deflected it, thence directly southward again. It continued to sap westward, pushing the bluff backward as a shoulder, until it cut into the Whitewater valley. It may for a while have occupied the Whitewater valley either wholly or in part. This is indicated by the fact that the Drum lowland is broader than the combined valleys of Whitewater river and Crooked creek. It was probably widened by an arm of the Mississippi. This took place evidently before the first capture of the Mississippi. It was taking place while Wolf creek and Caney creek were being captured and their valleys deepened.

6. *Capture of Castor River*

Castor river now crosses the Advance lowland, then enters and crosses Crowley ridge in a valley no wider than the size of the stream warrants. This can not have been its original course. When the Advance lowland was occupied by the Mississippi river, Castor river flowed into the latter stream, and its waters turned down the west side of Crowley ridge. It manifestly could not have crossed the Mississippi and followed its existing course. The latter is the result of a change subsequent to the abandonment of the Advance lowland by the Mississippi. It seems that, for a long time after this abandonment, Castor continued to follow the Advance lowland. That part of the Advance lowland lying between the St. Francis river and Castor, and known as Mingo swamp, is a low flat plain, with a surface deposit like that now being deposited by Castor and unlike the old Mississippi alluvium at Advance. There are no streams tributary to this belt between the two streams named that are large enough to form a deposit uniformly over the whole valley. They are all mere rivulets and could do nothing more than build flat alluvial cones, extending out into the plain from the bases of the bluffs, while the central belt would remain unaffected. The clay alluvium has no such distribution here. It could have been arranged only by a stream of considerable size, which had the ability to remove the top of the old sandy deposits and redeposit clay alluvium in its stead. The lowland, as has been stated above, slopes southwestward. The river must have flowed in this direction unless land warping has taken place in very recent times, of which no evidence is yet at hand.

Mingo creek is nothing more than an abandoned river channel that receives the drainage which runs into the lowland. It is about as wide as the channel of Castor river would be, after the banks had fallen in slightly. The water in this old channel has a very slow southwestward flow. It is as new apparently as many of the abandoned ox-bow curves along the existing course of this stream. While following this course, Castor river was held at a disadvantageous grade on account of the great distance it had to flow before reaching the Mississippi. A shorter course into the lower lying Morehouse lowland belt would be much more advantageous. We have already seen that in all probability Wolf creek was early captured by a northwardly growing tributary of Lick creek, and after excavating the Duck creek valley, was recaptured by the Mississippi. After the abandonment of the Advance lowland, Wolf creek became a tributary of Castor river, while the latter continued to follow the Advance belt southwestward. During all this time Wolf creek had opened a valley down to a low grade, across the hard limestones between Leora and the Advance lowland west of it, along the existing valley of Castor river. A small stream (T, Plate V), growing headward along the existing valley of Castor river between Leora and Zeta, working in the soft beds of the Tertiary, was able to tap Wolf creek near where it entered its narrow hard rock valley, and to offer it a steeper course to the Morehouse lowland and one in which hard rocks were avoided. It is probable, however, that the hardness of the rocks had little to do with the matter. Wolf creek was large enough and had occupied this valley long enough to have reduced the hard rocks to grade before it was turned eastward. The advantage gained because of the steeper slope seems to have been the determining factor.

This change left an abandoned valley of low grade only a few miles long, one end of the river channel in which communicated with the channel of Castor river, the other end with Wolf creek. Castor lay in the higher Advance lowland, Wolf creek flowed into the lower Morehouse lowland. During high floods in Castor river the flood waters probably found an outlet through this channel into Wolf creek and thence to the Morehouse lowland. This in time turned Castor in this direction.

These adjustments all took place after grade had been reached by the respective streams, and the differences in level were not sufficient to cause an important deepening of the channels and valleys of the captured streams. In the case of Castor, also, the hard rock over which it was let, has held it up, so far, to nearly its former level, above the point of capture. There is a low terrace in the valley west of Leora. There are two or more terraces in the valley east of Leora, but their significance was not worked out. The Advance lowland, where it was occupied by the Mississippi, when the latter followed the course of the Morehouse lowland, is about eight or ten feet lower than its level in the vicinity of Advance.

7. *Second Capture of the Mississippi*

Sexton creek (S, Plate V), like Wolf and Caney creeks, originally flowed westward into the Mississippi, entering the latter in what is now the bottom lands southeast of Cape Girardeau. It also had an upper course on soft rock and a lower on hard rock. Its upper course was held, therefore, at a high level by the inability of the stream to cut rapidly into the hard limestones down to a low grade. While waiting in such an exposed position, it was attacked by a stream (Y, Plate V) which had no such difficulties to contend with, and turned into the Ohio valley. A valley was soon excavated on the soft rock and extended well back beyond the point where the hard rock first appeared above its grade. At the point of capture, the level of the small valley was at about the level of the Mississippi. Here, also, the Mississippi was sapping the southeastern bluff, this being the convex side of the river curve. It finally cut into this valley, as it had already done at the point of capture of Caney and Wolf creeks, and found through it a still shorter course into the valley of the Ohio. This change took place so recently that the river has not yet had time to clear its channel of rocks, much less to form a flood plain (Plate II, No. 2).

At the point where the river leaves its old valley and enters the young one, the rocky bluffs descend down to the water on both sides. On the east side the bluff follows the river bank through the gorge. Immediately south of the entrance, the west bluff leaves the river and curves westward and southward, leaving a strip about a quarter of a mile wide between its base and the river. This is not steep, and the rocks do not outcrop abundantly on it. The low strip is not a flood plain of the Mississippi apparently, at least, not all of it. It is higher than the Mississippi flood plain and is not as sandy. It is not continuous southward either. It is local. It is without much doubt a locally widened part of the valley of Sexton creek after it was captured and turned southward. This was the turning point, and the valley was widened toward the west here by sapping on the convex side of the stream. The Mississippi, although it undoubtedly followed originally the lowest line of this valley, yet was unable to adjust itself to so sharp a turn, so that it gradually worked back eastward to its present position.

An examination of the map (Plate VI) shows that the line of the bluffs along the northern side of Benton ridge, does not fall into the line, when extended, of those north and east of Grays Point. A curved line, in other words, following the north bluffs of Benton ridge northeastward, when carried beyond Grays Point on the same curve, runs out onto the bottom lands at first, striking the bluffs several miles north of that place. This is doubtless due to a tributary of Sexton creek, which originally flowed into that stream from the northeastward along a course lying just west of the existing line of bluffs. The existing bluffs are, therefore, the eastern bluffs of that stream steepened by the Mississippi river. On account of this, the river was able to push further eastward here than elsewhere on this curve. It probably took place before the river was captured.

Another interpretation of the phenomenon would be that there was no small valley there, and that this lack of coincidence in the bluff lines on opposite sides of Grays Point is due to erosion of the bluffs, east of that place, by the river since it was captured. The curve in the bluffs on the west side of the river, just within the mouth of the gorge described above, may have been eroded by the Mississippi at this time where it turned from a southwestwardly to a southerly course. The narrowness of the gorge, even in the soft rocks of its southern end, is the strongest evidence against this interpretation.

Thus has the Mississippi, handicapped by the heavy load of sand thrown into it chiefly by the Missouri, found it necessary to abandon two valleys in succession, after each was eroded down to grade, and opened out to a width of several miles, in favor of the valleys of small creeks, which it had to work over and enlarge in order to make them suitable for its purpose. The amount of work that it has had to do has been increased by these changes, yet it has gained a shorter and more direct line to its destination. It has been engaged in the improvement of its line by straightening the curves. Large streams, as well as small ones, find means of getting themselves out of difficulties inherited from mistakes or unavoidable conditions of their early youth.

8. *Capture of St. Francis River*

St. Francis river, like Castor, originally flowed into the Mississippi while the latter occupied the Advance lowland. After the first capture of the Mississippi, the St. Francis continued to follow the lowland southward along with Black, Current, and other Ozark rivers. At the present time, however, it leaves this belt and crosses Crowley ridge at the state line into the Morehouse lowland. Its course through the ridge has been adopted recently. The width of the notch through which it finds its way across the ridge, is only about six hundred feet. The ridge just at this point or just at the north side of it is narrow also. It has not been mapped, but a hasty reconnaissance indicates that the ridge narrowed southward to the gap, where it was cut through by the sapping of the streams on opposite sides. There is no evidence of the process having been hastened by small tributary streams. The narrowness of the ridge makes such assistance improbable and unnecessary. The narrow valley through the ridge shows that the capture took place recently. The character of the St. Francis in the Morehouse lowland, south of where it enters it, shows also that the river has occupied its existing course so recently that it has not yet had time to establish a well defined channel. It spreads out over the lowland irregularly.

9. *Beheading of the Crowley Ridge Drainage*

A number of transverse belts of lowland across Crowley ridge were described above as "Minor Lowlands." They are merely the valleys of creeks which originally had their sources well to the east of the existing eastern side of the ridge. During this time they developed flood plains along their lower and middle courses. By the westward sapping of the Ohio river the heads of these streams were cut off and enough of their trunks to drive the line of bluffs backward so that it would cross them at points where their flood plains were well developed. They all have the remnant of the original stream occupying the portion that is left. They are narrow at the northern end of the ridge and wider at the southern. The beheaded valley of Lick creek at Idalia is about a quarter of a mile wide. That at Dexter is about half a mile, and one six miles south of the latter place is about a mile in width. The southern part of the ridge has been pushed further west of the original divide, apparently, than the northern part.

10. *Origin of Bird Hill and Its Associates*

The group of isolated hills including Bird, Lost, Cow, and Ringer hills are isolated portions of Crowley ridge. They are built up of exactly the same kind of rocks as it is, and the rocks have the same relative positions and the same attitude. Cow hill lies just within the crossing point of the projection of the southeastern and northern bluff lines of Crowley ridge. The others lie within these same lines, except the northern part of Lost hill, which projects a little north of it. The location of the latter hill was determined by hand-compass triangulation and may be not exactly right, though it is not far out of its true position. These hills constitute, therefore, a part of Crowley ridge, in which interlacing valleys constitute by far the larger part. Cow hill marks the northeastern corner of the ridge.

No solution that is entirely satisfactory has yet been found for the problem of their origin. The most probable one is that this area was originally occupied by a stream with rather widely branching tributaries. It may have flowed north or northwestward into the Mississippi, from a divide south of the ridge, or may have flowed southward from the northern part or north of the ridge. In the first case the stream and some branches were beheaded by the Ohio, and subsequent streams grew backward, inverting the drainage to a southerly direction. In the second case the Mississippi beheaded them, thus opening valleys through the ridge from the northern to the southern side of the ridge. In either case these valleys were afterward occupied and enlarged by arms of the Mississippi.

11. *"Sand Blows"*

At various points within the eastern part of the lowland region there are small areas in which the soil is a pure sand with very often small pieces of lignite scattered through it. They occur chiefly on Sikeston ridge and east of it. West of this their occurrence was not noticed during the field work. They vary in size, though they are often not more than twenty feet in diameter. The sand is so pure and so lacking in plant food that, where occurring in the fields, these spots remain bare of vegetation. They are thought by the farmers of the localities to be the results of eruptions from beneath. They occur within an area in which the surface or soil layer is a thin Loess-like or loamy deposit, underlain by a bed of pure loose sand, or else in an area underlain by a very sandy alluvium in general, on top of which has been spread a thin coating of clay since the region was abandoned by rivers having strong currents. Their existence seems to be due to a slight unconformity between the sand and overlying loam. The surface of the sand was slightly uneven when the loam was deposited on it, and the tops of some of the sand hills project through the layer of loam, either because they were never covered or have been uncovered by subsequent erosion.

The evidence, however, seems to be indisputable that during the earthquake shocks of 1811-12, there were points where the water spouted out of the ground to a height of several feet, carrying with it quantities of sand and lignite with black mud. This phenomenon is referred to in all the accounts of eye witnesses, and since such phenomena are known to accompany earthquake shocks in flood plains and deltas elsewhere, there is no reason to doubt their occurrence here. The "blows" may in some cases, therefore, be localities of such earthquake phenomena.

These with other phenomena that are popularly connected with the earthquake, need further investigation on the ground before definite conclusions can be announced.

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